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Methodologies for Countywide Estimation of Coal, Gas, and Organic Solvent Consumption

Abcor, Inc, Cambridge, Mass Walden Research Div

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U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

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I. INTRODUCTION

The Environmental Protection Agency has developed an extensive, nationwide data base of estimated air pollutant emissions from area and point sources. The data in this National Emission Data System (NEDS) require updating on a routine basis to provide current information for the EPA and other branches of government. The data on point sources is continually being updated by means of legal SIP reporting requirements on state agencies. There are no legal requirements, however, for states to make routine data submittals to update the area source data.

The objective of the current project was to develop methods for EPA to estimate fuel consumption information on a county-wide basis for area sources in the NEDS data bank. These techniques were then translated into computer programs to facilitate the application. The specific elements of the NEDS file that were considered are:

- Consumption by residential sources of natural gas, liquid petroleum gas (LPG), anthracite coal, and bituminous coal
- Consumption by commercial-institutional sources of natural gas, LPG, anthracite coal, and bituminous coal
- Consumption by industrial sources of natural gas, LPG, anthracite coal, and bituminous coal
- Consumption of gasoline and diesel fuel by off-highway sources
- Consumption of gasoline by marine vessels
- Consumption of diesel fuel by railroads
- Retail sales of gasoline

In addition, the project considered updating information on:

- Consumption of organic solvents
- Sulfur and ash content of anthracite coal and bituminous coal
- Landing and take-off cycles of military, civil, and commercial aircraft

The project plan was divided into two phases. The first phase was devoted to development of the methodology and testing on selected county data. The second phase included the collection and processing of 1973 data for all counties in the United States. This report describes the results of the first phase of the project. The data resulting from the second phase are available in the form of computer listings and magnetic tapes, as well as a coding manual [1] and a program documentation [2]. NEDS computer program listings containing data produced according to the methods described in this report may be obtained by contacting the Requests and Information Section, National Air Data Branch, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711.

The approach used by Walden to arrive at the county allocation methods was the development of basic relationships between fuel use and other demographic and economic factors. Statewide fuel consumption was distributed among the counties within each state based on the developed relationships. The resulting county-wide figures will serve to update corresponding figures of previous years presently available in NEDS format. Up-to-date air pollutant emissions estimates for area sources are calculated from these consumption figures by the NEDS computer programs.

The limitations of the resulting methods are summarized below:

(1) Demographic and economic data for the categories required by this study were often found to be incomplete or unavailable. Alternate, but less accurate methods were developed using the available information, introducing an error factor additional to the inaccuracy of some of the published data.

(2) The fuel crisis confronted by the United States has resulted in significant changes in the fuel consumption patterns across the nation. Lower thermostat settings in homes and businesses, shorter working hours, and the unavailability of motor fuels will have altered some of the correlative relationships developed here, based on historical data.

II. SUMMARY

A. METHODOLOGIES

Methodologies were developed for determining area source (county) quantities for the following NEDS area source data items:

Consumption by residential sources of bituminous coal, anthracite coal, natural gas, and LPG

Consumption by commercial-institutional sources of bituminous coal, anthracite coal, natural gas, and LPG

Consumption by industrial sources of bituminous coal and natural gas

Retail sales of gasoline

Consumption by off-highway sources of gasoline and diesel fuel

Consumption of diesel fuel by railroads

Marine consumption of gasoline

Organic solvent consumption

Sulfur and ash content of bituminous and anthracite coal

Aircraft landing and take-off cycles

The approach in developing the methodologies was based on the use of national, state, and county data items which are readily available, are updated periodically, and reflect variation of fuel use in time at both national and local levels. In general, the methodologies were designed to apportion county fuel use from published state totals. Two basic techniques were used. In some cases, equations were developed to estimate county consumption values which are then normalized to the published state totals. In other cases, the published state consumption is apportioned directly to the counties according to distribution of related demographic variables (e.g., population).

Several sources of state fuel use data report only a regional total for groups of states in some geographic regions. In such cases, related methodologies apply to the region as if it were a state comprised of the counties of the states included in the region.

Some data items were not available at the state level. In such cases, national figures were used, and the totals for counties in all states normalized against the national level.

In most instances, available fuel use figures pertain to total consumption. Thus, it is necessary to subtract corresponding point source values from the totals to obtain values representative of area sources. In all cases, the published state, regional, and national consumption figures are assumed to be correct. Estimated values, therefore, are normalized against published state totals that have been adjusted to account for point sources.

The methodologies for allocation of each data item are summarized in this section. Additional information, including background related to the derivation of the algorithms summarized in this section, is given in Section III and the Appendices. The overall scheme for processing of the data for NEDS is discussed in Section IV.

1. Fuel Consumption by Residential Sources

a. Natural Gas and Liquified Petroleum Gas (LPG)

Consumption of natural gas reported in the NEDS area source data is actually the combined total of natural gas and LPG. However, separate methodologies were developed for these two fuels. The results of the LPG methodology are, therefore, converted to a natural gas equivalent and added to the natural gas consumption value.

County natural gas consumption by residential sources is calculated by means of the formula

$$T_g = 47.5 * U_g * D^{0.367} * \left(\frac{U_{gh}}{U_x}\right)^{0.588} * R_d^{0.125}$$

where T_g = county consumption of natural gas in therms

D = annual degree days for the county [3]

U_g = number of occupied dwelling units in the county using gas [4]

U_{gh} = number of occupied dwelling units in the county using gas for space heating [4]

U_x = larger of the number of occupied dwelling units in the county using gas for cooking or hot water [4]

R_d = median number of rooms per dwelling unit in the county [5]

This estimate is then normalized against the reported state consumption:

$$NG_c = T_g * \frac{NG_s}{T_s}$$

where NG_c = normalized county natural gas consumption (10^6 cu.ft.)

NG_s = published state residential natural gas consumption (10^6 cu.ft.) [6]

T_s = sum of calculated county consumption (T_g) for all counties in the state (therms)

County LPG consumption by residential sources is calculated using the formula

$$T_\ell = (376 + 0.209D)U_\ell + \bar{c}_w * U_{\ell w} + \bar{c}_r * U_{\ell r}$$

where T_ℓ = county consumption of LPG by residential sources (therms)

D = annual degree days for the county [3]

U_ℓ = total dwelling units in the county using LPG [4]

$\bar{c}_w$ = regional average water heater consumption (therms) [7]

$U_{\ell w}$ = number of dwelling units in the county using LPG for heating water [4]

$\bar{c}_r$ = regional average cooking range consumption (therms)[7]

$U_{\ell r}$ = number of dwelling units in the county using LPG for cooking [4]

No sources were found that report state residential LPG consumption. However, retail (commercial and residential combined) figures are published [8]. State commercial point source LPG consumption is subtracted from the published state retail total, yielding state retail area source LPG consumption. The computed county figures (T_ℓ) are converted to kilogallons and summed over the state:

$$L_c = 0.00105\ T_\ell$$

and

$$L_s = \sum_c L_c$$

where

0.00105 = conversion factor from therms to kilogallons of LPG

L_c = estimated county residential LPG consumption (kilogallons)

T_ℓ = estimated county residential LPG consumption (therms)

L_s = estimated state total residential LPG consumption (kilogallons)

If the estimated state residential LPG consumption exceeds the state retail area source LPG consumption figure, the county consumption figures are normalized against the state retail area source value. Otherwise, the county LPG consumption estimate is left unchanged, and the remainder of the state area source retail LPG is used by the allocation methodology for commercial LPG consumption.

The total gas equivalent is computed by converting the final county residential LPG consumption estimate from 10^3 gallons to a natural gas equivalent in 10^6 cu.ft. and adding that value to the normalized county natural gas consumption.

$$TGE_c = NG_c + 0.0922 * L'_c$$

where TGE_c = county residential area source total gas equivalent consumption (10^6 cu.ft.)

NG_c = normalized county residential natural gas consumption (10^6 cu.ft.)

0.0922 = factor to convert LPG in 10^3 gal. to natural gas equivalent in 10^6 cu.ft. (Ratio of the heat equivalent of 10^6 cubic feet of natural gas to the heat equivalent of 10^3 gallons of LPG)

L'_c = final county residential LPG consumption (10^3 gal.)

b. Bituminous and Anthracite Coal

Total county residential consumption of coal (anthracite and bituminous) is calculated using the formula

$$C = 0.00387 * U_{coal} * e^{\left(7.64 - \frac{1000.0}{D}\right)}$$

where C = county consumption of coal (anthracite and bituminous)

U_{coal} = number of occupied dwelling units in the county using coal for space heating

D = annual degree days for the county

Residential consumption of anthracite coal and bituminous coal is derived from the estimated total coal consumption by

$$a_c = f_a * C$$
$$b_c = (1 - f_a) * C$$

where a_c = estimated county residential anthracite coal consumption (tons)
b_c = estimated county residential bituminous coal consumption (tons)
C = estimated total county residential coal consumption (tons)
f_a = fraction of total state coal market that is anthracite coal

The county consumption estimates must be normalized against published state figures. No sources were found that report state residential bituminous or anthracite coal consumption. Data on state shipments of anthracite and bituminous coal for retail use are available, however [9,10]. A national retail bituminous coal consumption figure is also obtainable.* A factor for converting state shipments to consumption is calculated from the national consumption and the sum of the state bituminous coal shipments, and the factor is applied to each state coal shipment value. State commercial point source consumption of anthracite and bituminous coal is subtracted from the corresponding state retail consumption, yielding state retail area source fuel consumption values.

One of three conditions will arise at this point. The county consumption estimates for each coal type are summed over the state. If both of these estimated state residential consumption totals exceed their respective retail area source consumption figures, the county consumption estimates are normalized:

letting $a_s = \sum_c a_c$

$b_s = \sum_c b_c$

then $a'_c = a_c * \frac{A_s}{a_s}$

and $b'_c = b_c * \frac{B_s}{b_s}$

where a_c = estimated county residential anthracite coal consumption (tons)
b_c = estimated county residential bituminous coal consumption (tons)
A_s = state retail area source anthracite coal consumption (tons)[9]
B_s = state retail area source bituminous coal consumption (tons)[10]

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*See Appendix B.

a'_c = normalized county residential anthracite coal consumption (tons)
b'_c = normalized county residential bituminous coal consumption (tons)

For the case where the sum of the estimated county residential consumption figures exceeds the state retail area source consumption for one coal type and does not exceed the state retail area source consumption for the other, the excess computed consumption is distributed among the counties and added to the other coal type as follows:

with X_s = state retail area source consumption of one coal type (i.e., A_s or B_s)
Y_s = state retail area source consumption of the other coal type
x_c = calculated county residential area source consumption corresponding to coal type of X_s (i.e., a_c or b_c)
y_c = calculated county residential area source consumption corresponding to coal type of Y_s

Let $x_s = \sum_c x_c$ such that $x_s > X_s$

$y_s = \sum_c y_c$ such that $y_s < Y_s$

$\Delta x = x_s - X_s$

$\Delta y = Y_s - y_s$

If $\Delta x \leq \Delta y$, let $\Delta c = \Delta x$
If $\Delta x > \Delta y$, let $\Delta c = \Delta y$

Then

$$y'_c = y_c\left(1 + \frac{\Delta c}{Y_s}\right)$$

$$x'_c = x_c * \frac{x_s}{X_s}$$

where x'_c = normalized county residential consumption of coal type x (i.e., a'_c or b'_c)
y'_c = adjusted county residential consumption of coal type y

If the sum of county residential consumption estimates is less than the state retail area source consumption for both coal types, no adjustments are made (i.e., $a'_c = a_c$, and $b'_c = b_c$).

The final county residential area source consumption for each coal type (a'_c and b'_c) is summed over the state. These state totals are subtracted from the corresponding retail area source consumption. The remainders are the state commercial bituminous and anthracite coal, to be allocated according to the commercial coal methodologies.

2. Fuel Consumption by Commercial-Institutional Sources

The methodology for determining county fuel consumption of natural gas, LPG, anthracite coal, and bituminous coal by commercial and institutional area sources is performed in five stages.

a. Fuel consumption is calculated for each of five commercial-institutional subcategories using the following formulae:

$$T_1 = 126.5 * BEDS + 12.7 * D + 77.4 * E_1 - 5.72 \times 10^4$$

$$T_2 = 8.05 \times 10^{-17} R_0^{1.84} D^{3.99} (R_0 + 2.84 (R - R_0))$$

$$T_3 = 165 \ E_3 + 4.10 \ D - 1.81 \times 10^4$$

$$T_4 = 229 \ E_4 + 51.5 \ D - 2.94 \times 10^5$$

$$T_5 = 531 \ E_5 - 1.28 \times 10^4$$

where T_1 = Total fuel consumed in the county by hospitals (10^3 therms)
T_2 = Total fuel consumed in the county by hotels (10^3 therms)
T_3 = Total fuel consumed in the county by schools (10^3 therms)
T_4 = Total fuel consumed in the county by universities (10^3 therms)
T_5 = Total fuel consumed in the county by commercial laundries (10^3 therms)
D = Annual degree days for the county [3]
BEDS = Number of hospital beds in the county[11]
R = Number of hotel rooms in the county [12]
R_0 = 100 if $R > 100$
or R_0 = R if $R \leq 100$
E_1 = County hospital employment
E_3 = County school employment
E_4 = County university employment
E_5 = County commercial laundry employment [13]

The method for determining county employment for hospitals, universities, and schools is explained in Appendix B. Total fuel consumption in the county by the five commercial subcategories (T_c) is then computed:

$$T_c = \sum_{j=1}^{5} T_j$$

b. The estimated fuel consumption for the five commercial subcategories is summed over all counties in the state. This state total is broken down into natural gas, LPG, and coal consumption according to the proportion of occupied residential dwelling units in the state using those respective fuels for space heating:

Letting U_i = the number of occupied dwelling units heated by fuel type i (0 = fuel oil, 1 = natural gas, 2 = LPG, 3 = coal)

X_i = published or derived state commercial area source consumption of fuel type i,

$$T_s = \sum_c T_c$$

$$\text{and } U = U_0 + \sum_{i=1}^{3} (U_i : X_i > 0)$$

$$\text{then } T_{i,s} = T_s \frac{U_i}{U}$$

where $T_{i,s}$ = State consumption of fuel type i by five commercial subcategories (terms)

Dwelling units using fuel oil for space heating are included in the dwelling unit total to account for fuel oil consumed by commercial sources in the fuel consumption total.

c. The state five commercial subcategory consumption for each fuel type is converted from therms to the standard NEDS units for that fuel type (10^6 cu.ft. for natural gas, 10^3 gal. for LPG, tons for coal). Coal consumption is then split between anthracite and bituminous according to the proportions of the state commercial area source consumption of each coal type remaining from the input retail value after conversion from shipments and subtracting normalized residential consumption and commercial point source consumption (see Section II.A.1.b).

$$F_1 = 9.69 \times 10^{-5} T_1$$

$$F_2 = 1.05 \times 10^{-3} T_2$$

$$F_3 = 4.08 \times 10^{-6} \left(\frac{a_s}{a_s + b_s}\right) * T_3$$

$$F_4 = 3.82 \times 10^{-6} \left(\frac{b_s}{a_s + b_s}\right) * T_4$$

where F_i = State consumption of fuel type is by the five commercial subcategories in the standard NEDS units of that fuel type ($i = 1$ for natural gas, $i = 2$ for LPG, $i = 3$ for anthracite coal, $i = 4$ for bituminous coal)

a_s = Actual state commercial area source consumption of anthracite coal (tons)

b_s = Actual state commercial area source consumption of bituminous coal (tons)

9.69×10^{-5} = Factor to convert therms to 10^6 cu.ft. of natural gas

9.05×10^{-3} = Factor to convert therms to 10^3 gal. of LPG

4.08×10^{-6} = Factor to convert therms to tons of anthracite coal

3.82×10^{-6} = Factor to convert therms to tons of bituminous coal

d. Next, state consumption of each fuel type by all commercial sources other than the five subcategories are computed. Normalization factors are also computed.

Actual state commercial area source consumption of each fuel type is derived directly from published values. State commercial area source natural gas is the total commercial natural gas consumption[5] less the commercial point source natural gas consumption. State consumption of LPG, anthracite coal, and bituminous coal are the remainder of state retail fuel consumption after subtacting state commercial point source consumption and normalized state residential consumption for the respective fuel types (see Section II.A.1.a and II.A.1.b).

State fuel consumption of all commercial sources other than the five commercial subcategories is calculated as follows:

If $X_i > F_i$, then $FO_i = X_i - F_i$ and $n_i = 1$

If $X_i \leq F_i$, then $FO_i = 0$ and $n_i = \frac{X_i}{F_i}$

where FO_i = State consumption by "other" commercial sources of fuel type i

X_i = Actual state commercial area source consumption of fuel type i

F_i = Calculated state five commercial subcategory consumption of fuel type i

n_i = Normalization factor for consumption of fuel type i by five commercial subcategories

e. Finally, the county commercial consumption is calculated.

$$F_{i,c} = n_i f_i T_{i,c} \left(\frac{U_{i,c}}{U_c}\right) + FO_i \frac{E_c}{E_s}$$

where $F_{i,c}$ = Normalized county consumption of fuel type i by commercial area source (in the standard NEDS units of fuel type i)

n_i = Normalization factor for consumption of fuel type i by the five commercial subcategories

f_i = Factor to convert consumption from therms to the NEDS standard units for fuel type i

$T_{i,c}$ = Total county fuel consumption by the five commercial subcategories (therms)

$U_{i,c}$ = Number of occupied dwelling units in county c using fuel type i for space heating [4]

$$U_c = \sum_{i=1}^{4} (U_{i,c} : T_i > 0) + U_{o,c}$$

= Total number of dwelling units in the county using fuels for space heating that are also used by commercial sources. This includes dwelling units using fuel oil. ($U_{o,c}$).

FO_i = State consumption of fuel type i by all commercial sources except the five subcategories

E_c = County area source employment for all commercial sources except the five subcategories

E_s = State area source employment for all commercial sources except the five subcategories

3. Fuel Consumption by Industrial Sources

The procedure for estimating natural gas and bituminous coal consumption by industrial area sources involves four steps. Essentially all anthracite coal consumed by industry is by point sources, so no allocation is performed for that fuel type. Industrial consumption of LPG is not estimated separately, but is combined with the state natural gas total prior to apportionment to the county's level.

a. State fuel intensity ratios are computed for each fuel type by each of SIC categories 20-39 (in this study, SIC category 39 will represent the combination of SIC 39 and SIC 19), using the most recent Census of Manufactures fuel use data [14] and employment data for the corresponding year from the County Business Patterns [13].

$$FIR_{ij} = F_{ij}/E_j$$

where FIR_{ij} = The fuel intensity ratio for fuel type i and SIC category j

F_{ij} = State consumption of fuel type i by SIC category [14]

E_j = State employment of SIC category j [13]

b. The fuel intensity ratios give a measure of fuel use intensity per employee. By applying the state fuel intensity ratios to corresponding county area source employment figures, and summing over the 20 SIC categories, an estimate of county industrial fuel consumption is obtained:

$$F_{i,c} = \sum_{j=1}^{20} E_{j,c}\, FIR_{ij}$$

where $F_{i,c}$ = County industrial area source consumption of fuel type i

$E_{j,c}$ = Total employment in county c for SIC j (CBP) minus point source employment in county c for SIC j (NEDS)

FIR_{ij} = State fuel intensity ratio for fuel type i and SIC category j

c. Actual state industrial area source consumption of natural gas (including LPG) and bituminous coal are derived from state totals and point source consumption figures as follows:

$$X_1 = (G - G_p) + f(L - L_p)$$

and $$X_2 = \frac{B_n}{\Sigma B_s} (B_s - B_p)$$

where X_1 = Statewide total gas equivalent consumption by industrial area sources

X_2 = Statewide consumption of bituminous coal by industrial area sources

G = Total state industrial natural gas sales [6]

G_p = Statewide natural gas consumption by industrial point sources (NEDS)

L = Total state industrial LPG sales [8]

L_p = Statewide LPG consumption by industrial point sources (NEDS)

f = Factor to convert LPG to natural gas equivalent

B_n = Published national total consumption of bituminous coal by industrial sources [10]

B_s = Published state shipments of bituminous coal for industrial consumption

B_p = Statewide consumption of bituminous coal by industrial point sources (NEDS)

d. County industrial area source fuel consumption estimates are normalized against the actual state consumption:

$$F'_{i,c} = F_{i,c}\left(\frac{X_i}{F_i} \right)$$

where $F'_{i,c}$ = Normalized county industrial area source consumption of fuel type i

$F_{i,c}$ = Estimated county industrial area source consumption of fuel type i

$F_i = \sum_c F_{i,c}$

X_i = Actual state industrial area source consumption of fuel type i

4. Consumption of Gasoline and Diesel Fuel by Off-Highway Sources

Off-highway sources have been divided into six categories: farm equipment, construction equipment, industrial equipment, motorcycles, lawn and garden equipment, and snowmobiles. Consumption in each category is estimated by either of two general approaches:

- Apportionment of a national fuel consumption total to counties on the basis of employment, population etc.
- Calculation of county or state totals by applying fuel consumption rates to average usage figures and equipment populations.

Total off-highway consumption of gasoline and diesel fuel is the sum of the consumption estimates of the individual categories as follows:

$$G = \sum_{j=1}^{6} F_{1,j}$$

$$DF = \sum_{j=1}^{3} F_{2,j}$$

where G = Off-highway consumption of gasoline (10^3 gal.)

DF = Off-highway consumption of diesel fuel (10^3 gal.)

F_{ij} = Consumption of fuel type i ($i = 1$ for gasoline, $i = 2$ for diesel fuel) by off-highway category j ($j = 1$ for farm equipment, $j = 2$ for construction equipment, $j = 3$ for industrial equipment, $j = 4$ for motorcycles, $j = 5$ for lawn and garden equipment, and $j = 6$ for snowmobiles)

A description of the methodologies for estimation of fuel consumed by each off-highway category follows:

a. Farm Equipment

Consumption of gasoline and diesel fuel by farm equipment is apportioned to individual counties from an estimated state farm equipment consumption on the basis of tractor population. To estimate state fuel consumption by farm equipment, consumption values are calculated separately for each of five equipment subcategories: farm tractors, combines, motorized balers. forage harvesters, and general-purpose large utility engines. The methodology for estimating state fuel consumption by farm equipment is expressed as:

$$F_{s,i} = \sum_{j=1}^{5} f_{ij} N_j A_{ij} FR_{ij} \qquad \text{(i)}$$

where $F_{s,i}$ = State consumption of fuel type i (i = 1 for gasoline, i = 2 for diesel fuel) by farm equipment (gal.)

f_{ij} = Fraction of farm equipment subcategory j in the state that is powered by fuel type i (j = 1 for tractors, j = 2 for combines, j = 3 for motorized balers, j = 4 for forage harvesters, j = 5 for general-purpose large utility engines)[15]

N_j = State population of farm equipment in subcategory j[16]

A_{ij} = Average annual usage of equipment in subcategory j using fuel type i (hours/year)[15]

FR_{ij} = Average hourly consumption of fuel type i per unit of equipment in subcategory j (gals./hour) [15]

With the exception of the general-purpose large utility engine category, equipment populations are obtained from the Census of Agriculture [16]. The large utility engine population is estimated from the distribution of tractor populations in irrigated and non-irrigated areas:

$$N_5 = 0.30N_1\left(\frac{IR}{IR+NIR}\right) + 0.05N_1\left(\frac{NIR}{IR+NIR}\right) \qquad \text{(ii)}$$

where N_1 = Number of tractors in the state

IR = Number of farms in the state in irrigated areas

NIR = Number of farms in the state in non-irrigated areas

The estimated large utility engine population is apportioned by fuel type according to the proportions of tractors that are powered by gasoline and diesel fuel.

County consumption of gasoline and diesel fuel by farm equipment is determined by:

$$F_{i1} = F_{s,i} \frac{N_c}{N_1} \qquad \text{(iii)}$$

where F_{i1} = County consumption of fuel type i by farm equipment

$F_{s,i}$ = State consumption of fuel type i by farm equipment

N_c = County tractor population [17]

N_1 = State tractor population

b. Construction Equipment

County consumption of gasoline and diesel fuel by construction equipment are allocated from the state construction equipment consumption on the basis of population. State fuel consumption is estimated by apportioning national fuel consumption according to total non-building construction employment. (i.e., employment in heavy construction (SIC 1600) and special trade (SIC 1700) categories)

$$F_{i,2} = F_{N,i}\left(\frac{E_s}{E_N}\right)\left(\frac{P_c}{P_s}\right)$$

where $F_{i,2}$ = County consumption of fuel type i by construction equipment (gal.)

$F_{N,i}$ = National consumption of fuel type i by construction equipment (gal.) [14]

E_s = State non-building employment [13]

E_N = National non-building employment [13]

P_c = County population [4]

P_s = State population [4]

c. Industrial Equipment

The methodology for estimating consumption of gasoline and diesel fuel by industrial equipment is expressed as:

$$F_{i,3} = F_{N,i}\left(\frac{E_{c,mmw}}{E_{N,mmw}}\right)$$

where $F_{i,3}$ = County consumption of fuel type i by industrial equipment

$F_{N,i}$ = National consumption of fuel type i by industrial equipment [18]

$E_{N,mmw}$ = Total county employment in manufacturing, mining, and wholesale trade [13]

$E_{N,mmw}$ = Total national employment in manufacturing, mining, and wholesale trade [13]

d. Motorcycles

County gasoline consumption by motorcycles is estimated from state consumption on the basis of population:

$$F_{1,4} = \frac{P_c}{P_s}\left(M * FR * (f_1u_1 + f_2u_2)\right)$$

where $F_{1,4}$ = County consumption of gasoline by motorcycles (gal.)
P_c = County population [19]
P_s = State population [19]
M = State motorcycle registrations [20]
FR = Motorcycle fuel consumption rate (gal./mile)[18]
f_1 = Fraction of motorcycles that are off-road [21]
u_1 = Average annual usage of off-road motorcycles (miles/year)
f_2 = Fraction of motorcycles that are combination [21]
u_2 = Average annual usage of combination motorcycles [21] (miles/year)

e. Lawn and Garden Equipment

County lawn and garden equipment consumption of gasoline is derived from national totals of lawn and garden equipment consumption of gasoline and snowthrower consumption of gasoline:

$$F_{1,5} = F_{N,LG}\left(\frac{U1_c}{U1_N}\right)\left(\frac{FFD_c}{FFD_N}\right) + K\cdot F_{N,SN}\left(\frac{P_c}{P_{SZ}}\right)\left(\frac{S_c}{S_{SZ}}\right)$$

where $F_{1,5}$ = County consumption of gasoline by lawn and garden equipment (gal.)
$F_{N,LG}$ = National consumption of gasoline by lawn and garden equipment other than showthrowers (gal.)[18]
$U1_c$ = Number of dwelling units in single-unit structures in the county [5]
$U1_N$ = Number of dwelling units in single-unit structures in the nation [5]

FFD_c = Number of freeze-free days (minimum temperature > 32°F) in the county [3]

$FFD_N = \sum_c FFD_c$ for all counties in the nation

K = 0 for counties with annual snowfall < 30 inches
= 1 for counties with annual snowfall > 30 inches

$F_{N,SN}$ = National consumption of gasoline by snowthrowers [18] (gal.)

S_c = County snowfall [3]

$S = \sum_c (S_c : S_c > 30$ inches) (snow zone snowfall; the snow zone is all areas with annual snowfall > 30 inches)

P_c = County population [19]

$P_{SZ} = \sum_c (P_c : S_c > 30$ inches) (snow zone population)

f. Snowmobiles

County consumption of gasoline by snowmobiles is derived from the national snowmobile gasoline consumption total on the basis of the counties' share of the snowmobile population. County snowmobile population is estimated from state snowmobile registrations using one of two formulae. The formulae compute the fraction of state snowmobiles that are located in the county. The formula used is determined by the population density of the county:

(1) For counties with population densities that are less than 1,000 inhabitants per square mile,

$$f_c = 1.56 * \left(\frac{P_c}{P_s}\right) + 0.0321 \left(\frac{S_c}{S_o}\right) - 0.0234 \qquad \text{(i)}$$

(2) For counties with population densities that are greater than or equal to 1,000 inhabitants per square mile,

$$f_c = K \frac{P_c}{P_s} [1.5 - 0.0005\, \rho_c] \qquad \text{(ii)}$$

where f_c = Fraction of state's snowmobiles that are located in county c

P_c = County population [19]

P_s = State population

S_c = County snowfall [3]

S_o = Snowfall at center of the state (centroid county snowfall)

ρ_c = county population density (inhabitants/square mile) [5]

$K = 0$ for $\rho_c > 3,000$

$K = 1$ for $1,000 \leq \rho_c \leq 3,000$

The county snowmobile population is then computed:

$$N_{c,sm} = f_c N_{s,sm} \qquad \text{(iii)}$$

where $N_{c,sm}$ = Number of snowmobiles in county c

$N_{s,sm}$ = State snowmobile registrations

The county consumption of gasoline by snowmobiles is then apportioned from the national snowmobile gasoline consumption total:

$$F_{1,6} = F_{N,sm} \left(\frac{N_{c,sm}}{N_{N,sm}}\right) \qquad \text{(iv)}$$

where $F_{1,6}$ = County consumption of gasoline by snowmobiles (gal.)

$F_{N,sm}$ = National consumption of gasoline by snowmobiles (gal.) [13]

$N_{c,sm}$ = County snowmobile population

$N_{N,sm}$ = National snowmobile population

5. Consumption of Gasoline by Marine Vessels

County marine consumption of gasoline is apportioned from state marine gasoline consumption on the basis of inland water area and coastline:

$$G_v = \left(\frac{W_c + f * L_c}{W_s + f * L_s}\right) [10 * m_c(N_{v1}FR_{v1} + N_{v2}FR_{v2})]$$

where G_v = County consumption of gasoline by marine vessels (gal.)
W_c = County inland water area [22]
W_s = State inland water area [22]
f = Factor for converting coastline to inland water area
L_c = County coastline
L_s = State coastline
m_c = Number of warm months (which promote boating activities).[3] This is assumed to be the number of months during which the monthly normal temperatures exceed 45°F for counties north of 43° latitude, 48°F for counties between 37° and 43° latitude, and 55°F for latitudes south of 37° latitude.
N_{v1} = State inboard boat registrations [23]
FR_{v1} = Average fuel consumption rate of inboard boats (gal/hour)[15]
N_{v2} = State outboard boat registrations[24]
FR_{v2} = Average fuel consumption rate of outboard boats (gal/hour)[15]

6. Consumption of Diesel Fuel by Railroads

County consumption of diesel fuel by railroads is apportioned from published state consumption on the basis of population distribution:

$$DF_{c,r} = DF_{s,r} \times (\frac{P_c}{P_s})$$

where $DF_{c,r}$ = County consumption of diesel fuel by railroads (10^3 gal.)
$DF_{s,r}$ = State consumption of diesel fuel by railroads (10^3 gal.)[25]
P_c = County population [19]
P_s = State population

7. Retail Sales of Gasoline

Some states report retail gasoline sales (volume) by county. For these states, the reported county figures are used directly. For states that do not report county retail gasoline sales, a methodology has been developed that estimates county sales from reported state retail sales of gasoline, reported state aviation gasoline sales, and computed consumption of gasoline by various off-highway categories.

$$V_c = V_h(\frac{r_c}{r_s}) + \sum_{j=1}^{3} F_{1,j} + V_a(\frac{LTO_c}{LTO_s})$$

where V_c = County retail sales of gasoline (10^3 gal.)
V_h = State retail sales of gasoline for highway and marine use (10^3 gal.)
r_c = Gross receipts of gasoline service stations in county [26]
r_s = Gross receipts of gasoline service stations in state
$F_{i,j}$ = County consumption of gasoline (10^3 gal.) by off-highway category j (j = 1 for farm equipment, j = 2 for construction equipment, j = 3 for industrial equipment)
V_a = State aviation gasoline sales (10^3 gal.)
LTO_c = Total landing - take-off cycles in county for military, civil, and commercial aircraft
$LTO_s = \sum_c LTO_c$

The county consumption of gasoline by off-highway sources is determined using the methodologies described in Sections II.A.4.a, b, and c.

The state retail sales of gasoline for highway and marine use are derived from the reported state total retail sales by subtracting reported sales for agricultural, commercial, industrial, and aviation off-highway categories:

$$V_h = V_s - \left(\sum_{i=1}^{4} V_{OH,i} \right)$$

where V_h = State retail sales of gasoline for highway and marine use
V_s = Total state retail gasoline sales [20]
$V_{OH,i}$ = State retail sales of gasoline for off-highway category i (i = 1 for agricultural, i = 2 for commercial, i = 3 for industrial, and i = 4 for aviational)

8. Consumption of Organic Solvents

The methodology for allocating organic solvent consumption by county consists of apportioning national consumption of seventeen primary solvent groups by major user category according to county population or area source employment for the individual user categories. Total solvent consumption is the sum of the consumption value for each of the user categories. Table 2-1 contains a list of the primary solvent groups and corresponding user categories. Two of the major user categories, surface coatings and other use, are broken down into subcategories, as shown on the table.

TABLE 2-1

SOLVENT TYPES AND USER CATEGORIES

User Category (✓ designates solvents used)

			Surface Coatings												Degreasing	Dry Cleaning	Printing & Publishing	Rubber & Plastics	Other Use	
			Population	SIC 7535	SIC 371	SIC 25	SIC 34	SIC 35 & 36	SIC 26	SIC 243 & 244	SIC 37 less 371,373	SIC 36	Total Manufacturing	SIC 373					Total Manufacturing	Population
Solvent Type	i	j	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Special Naphthas	1		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓
Penchloroethylene	2														✓	✓			✓	✓
Ethanol	3		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					✓	✓
Trichloroethylene	4														✓		✓		✓	✓
Toluene	5		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						
Acetone	6		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					✓	✓
Xylene	7		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					✓	✓
Fluorocarbons	8																	✓	✓	✓
M.E.K.	9		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					✓	✓
1,1,1-Trichloroethane	10														✓			✓	✓	✓
Methylene Chloride	11		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓
Methanol	12																		✓	✓
Ethylene Dichloride	13		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓
Ethyl Acetate	14		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		

TABLE 2-1 (continued)

SOLVENT TYPES AND USER CATEGORIES

User Category (✓ designates solvents used)

			Surface Coatings												Degreasing	Dry Cleaning	Printing & Publishing	Rubber & Plastics	Other Use	
			Population	SIC 7535	SIC 371	SIC 25	SIC 34	SIC 35 & 36	SIC 26	SIC 243 & 244	SIC 37 less 371,373	SIC 36	Total Manufacturing	SIC 373					Total Manufacturing	Population
Solvent Type	i	j	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Cyclohexane	15		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		
M.I.B.K.	16		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓
All Other Solvents	17																		✓	✓

National consumption of the primary solvent groups is distributed to each of the user categories according to the percentage of solvent used by the user category:

$$S_{Nij} = S_i f_{ij}$$

where S_{Nij} = National consumption (tons) of solvent group i by user category j (Table 2-1 gives the subscript values corresponding to individual solvent groups and user categories.)

S_i = Published total national solvent group i [27,28]

f_{ij} = Percent of solvent group i that is consumed by user category j

The county consumption for each solvent group and user category is computed and summed to give the total county consumption:

$$S_c = \sum_{i=1}^{19} \sum_{j=1}^{18} \frac{(E_{cj} - P_{cj})}{(E_{Nj} - P_{Nj})} S_{Nij}$$

where S_c = Total county organic solvent consumption (tons)

S_{Nij} = National consumption of solvent type i by user category j (tons)

E_{cj} = Number of individuals (employment or population) in county c in user category j

E_{Nj} = Number of individuals in the nation in user category j

P_{cj} = Number of individuals in county c in point source user category j

P_{Nj} = Number of individuals in the nation in point source user category j

9. Sulfur and Ash Content of Coal

Separate methodologies were developed for estimating sulfur and ash content of bituminous coal and anthracite coal used by area sources in each county.

a. Bituminous Coal

(1) Determine average sulfur and ash content of bituminous coal shipped from each production district or production district grouping for use by retail and industrial sources.

The Bureau of Mines annually reports sulfur content and shipments of coal from each of 23 production districts for consumption by each of five user categories, namely, Electric Utilities, Coke and Gas Plants, Other Industrial User and Retail Dealers, All Other Users, and Exports [75]. A weighted average for each production district of sulfur content for the Other Industrial Users and Retail Dealers and the All Other Users categories gives a representative value of sulfur content of bituminous coal shipped for use by retail and industrial sources, excluding electric utilities and coke and gas plants. Shipments to each state are reported by the Bureau of Mines for 18 production districts and two production district groupings [10]. Shipments to each state from districts 3 and 6 are reported as one grouping, and shipments to each state from districts 22 and 23 are reported as another grouping. Shipments from production district 5 to each state are not reported. The two production district groupings are treated as single districts. Average sulfur content of coal shipped from each district or district grouping for consumption by retail and industrial sources (excluding electric utilities and coke and gas plants) is completed as follows:

$$f_{1,i} = \frac{W_{i_1} S_{i_1} + W_{i_2} S_{i_2}}{W_{i_1} + W_{i_2}}$$

where $f_{1,i}$ = Sulfur content of coal shipped from production district i for use by retail and industrial sources (%)

W_{i_1} = Shipments of bituminous coal from district i for use by the Other Industrial Uses and Retail Dealers category [75]

W_{i_2} = Shipments of bituminous coal from district i for use by the All Other Uses category [75]

S_{i_1} = Sulfur content of coal from district i for use by the Other Industrial Uses and Retail Dealers category (%) [75]

S_{i_2} = Sulfur content of coal from district i for use by the All Other Uses category [75] or, for production district grouping i comprised of districts j and k,

$$f_{1,i} = \frac{W_{j_1}S_{j_1} + W_{k_1}S_{k_1} + W_{j_2}S_{j_2} + W_{k_2}S_{k_2}}{W_{j_1} + W_{k_1} + W_{j_2} + W_{k_2}}$$

Ash content of bituminous coal from each production district is computed by averaging the ash content of coal produced by mines sampled in the district [47]:

$$A_j = \frac{1}{n} \sum_{k=1}^{n} a_k$$

where a_k = Ash content of coal from the $k^{\underline{th}}$ mine in district j (%) [47]

n = number of mines sampled in district j [47]

A_j = Average ash content of bituminous coal from district j (%)

Average ash content of coal from the two production district groupings are then computed:

$$F_{2,i} = \frac{(W_{j_1} + W_{j_2})\, A_j + (W_{k_1} + W_{k_2})\, A_k}{W_{j_1} + W_{j_2} + W_{k_1} + W_{k_2}}$$

where $f_{2,i}$ = Ash content of coal from production district grouping i composed of districts j and k (%)

For the 18 production districts that are not grouped,

$$f_{2,i} = A_i$$

(2) State averages of sulfur and ash content are computed separately for coal shipped for use by retail area sources and coal shipped for industrial area sources. Coal shipments to each state from each production district/district grouping are reported separately for retail users and industrial users excluding electric utilities and coke and gas plants. Sulfur and ash, by weight, in coal used by commercial and industrial point sources is available from the NEDS point source data. Average sulfur and ash content of coal shipped to each state is calculated by user category as follows:

$$x_{ij} = 100X \frac{\left(0.01 \sum_{k=1}^{20} f_{ik}c_{jk}\right) - x_{p,ij}}{\left(\sum_{k=1}^{20} i \; c_{jk}\right) - c_{p,ij}}$$

where i = 1 for sulfur, 2 for ash

j = 1 for retail, 2 for industrial excluding electric utilities and coke and gas plants

k = production district/district grouping number

x_{ij} = Sulfur (i=1) or ash (i=2) content of coal shipped to the state for use by area sources in user category j (%)

f_{ik} = Average sulfur or ash content of coal from production district/district grouping k for use by retail and industrial services (%)

c_{jk} = Coal shipments to the state from production district/district grouping k for user category j (10^3 tons) [10]

$x_{p,ij}$ = Sulfur or ash by weight in bituminous coal consumed in the state by point sources in in user category j (10^3 tons) (NEDS)

$c_{p,ij}$ = Bituminous coal consumed in the state by point sources in user category j (10^3 tons) (NEDS)

(3) Countywide sulfur and ash content are apportioned from state sulfur and ash content according to the relative mix of coal used in the county by retail and industrial area sources:

$$y_i = \frac{\sum_{j=1}^{2} x_{ij}\, b'_{cj}}{\sum_{j=1}^{2} b'_{cj}}$$

where y_i = Sulfur (i = 1) or ash (i = 2) content of bituminous coal used in the county (%)

b'_{cj} = County consumption of bituminous coal by retail (j = 1) or industrial (j = 2) sources

x_{ij} = Sulfur (i=1) or ash (i=2) content of coal shipped to the state for use by area sources in user category j (%)

The value of b'_{c1} is the sum of the normalized county residential and commercial bituminous coal consumption, which was calculated using the methodologies described in Sections II.A.1.b and II.A.2. The value of b'_{c2} is the normalized county industrial consumption calculated using the methodology described in Section II.A.1.c.

b. Sulfur and Ash Content of Athracite Coal

Because there is only one anthracite producing region in the country (located in Southeastern Pennsylvania), one value each for sulfur content and ash content is used for all counties. The values are obtained from the Bureau of Mines publication, "Distribution of Pennsylvania Anthracite" [9].

10. Aircraft Landing and Take-Off Cycles

County landing and take-off cycles (LTOs) are calculated separately for civil, commercial, and military aircraft categories. One of two methods is used to determine county LTOs.

a. For counties with FAA regulated airports and/or military airports, LTOs are derived directly from reported operations:

$$LTO_i = 0.5 \times O_i$$

where LTO_i = County LTOs for aircraft category i (i = 1 for commercial aircraft, i = 2 for civil aircraft, i = 3 for military aircraft)

O_i = Total operations in county for aircraft category i

b. For counties with no FAA regulated airports or miliary airports, all operations in the county are assumed to involve civil aircraft only. The number of LTOs for civil aircraft is calculated from the county aircraft registrations:

$$LTO_2 = 365 * N$$

where N = the number of aircraft registered in the county.

B. THE DATA BASE

The data base for the allocation methodologies is divided into three major categories:

- National and regional data
- State data
- County data

Whenever possible, Walden has attempted to use data which are updated annually or more often. The national and regional data include national and regional fuel consumption figures, fuel consumption rates, and sulfur and ash contents. The state data include fuel consumption, socioeconomic, climatological, and demographic figures. The county data include primarily climatological and demographic data. Tables 2-2, 2-3, and 2-4 contain a list of all data items required for the allocation methodologies.

Table 2-5 summarizes the major sources used for obtaining data. Table 2-6 lists the contacts made with the various state highway or tax department offices throughout the country. Table 2-7 lists sources for data available on magnetic tape. Other sources are referenced throughout this report, but the sources in Tables 2-5, 2-6, and 2-7 are essential to prepare the input to the computer programs that perform the fuel use allocations. State fuel use figures were primarily taken from Bureau of Mines publications. Other sources used include Highway Statistics, published yearly by the Federal Highway Administration, and Synthetic Organic Chemicals, published yearly by the United States Traffic Commission.

TABLE 2-2

NATIONAL VARIABLES FOR ALLOCATION METHODOLOGIES

Description of Variable (Units) .
Industry sulfur content of coal, production districts 1-23 (%)
Other sulfur content of coal, production districts 1-23 (%)
Industry coal production, production districts 1-23 (tons x 10^5)
Other coal production, production districts 1-23 (tons x 10^5)
Ash content of bituminous coal, production districts 1-18 (%)
Ash content of bituminous coal, production districts 19-23 (%)
Sulfur content of anthracite coal (%)
Ash content of anthracite coal (%)
Annual usage of diesel tractors (hours/year)
Annual usage of gasoline tractors (hours/year)
Annual usage of general purpose--agricultural--equipment (hours/year)
Annual usage of harvesters (hours/year)
Annual usage of bailers (hours/year)
Annual usage of combines (hours/year)
Average gasoline consumption rate, tractors (gallons/year)
Average gasoline consumption rate, general purpose (gallons/year)
Average gasoline consumption rate, harvesters (gallons/year)
Average gasoline consumption rate, balers (gallons/year)
Average gasoline consumption rate, combines (gallons/year)
Percent tractors using gasoline fuel (%)
Percent tractors using diesel fuel (%)
Percent using gasoline, general purpose--agricultural (%)
Percent using gasoline, harvesters (%)
Percent using gasoline, balers (%)
Percent using gasoline, combines (%)
Fuel consumption, construction--gasoline (gallons x 10^3)
Fuel consumption, construction--diesel (gallons x 10^3)
Fuel consumption, industrial--gasoline (gallons x 10^3)
Fuel consumption, industrial--diesel (gallons x 10^3)

TABLE 2-2 (continued)

NATIONAL VARIABLES FOR ALLOCATION METHODOLOGIES

Description of Variable (Units)
Fuel consumption, lawn and garden (gallons x 10^3)
Fuel consumption, snowthrowers (gallons x 10^3)
Fuel consumption, snowmobiles (gallons x 10^3)
Usage--motorcycles, off road (miles/year)
Usage--motorcycles, combination (miles/year)
Gas mileage, motorcycles (miles/gallon)
Gas usage, inboard boats (gallons/hour)
Gas usage, outboard boats (gallons/hour)
Gas consumption by census region, cooking range (therms/year)
Gas consumption by census region, water heater (therms/year)
Regional percentage, off-road motorcycles (%)
Regional percentage, combination motorcycles (%)
Growth by census region in LPG heat (%)
Growth by census region in LPG cooking (%)
Growth by census region in coal heat (%)
Solvent consumption by primary solvent group (pounds x 10^6)
Bituminous coal consumption, steel mills (tons x 10^3)
Bituminous coal consumption, cement plants (tons x 10^3)
Bituminous coal consumption, other industrial (tons x 10^3)
Bituminous coal consumption, retail (tons x 10^3)
1971 industrial coal consumption, SIC 20-39, 19, and 39 (tons x 10^2)
1971 industrial natural gas consumption, SIC 20-38, 19, and 39 (ft^3 x 10^6)
1971 industrial employment, SIC 20-38, 19, and 39
Univeristy employment/enrollment ratio
Solvent point source employment, SIC 26, 26, 27, 30, 24-39, total 19-39, laundries, 243, 244, 371, 373, 7535, 264, 265

TABLE 2-3

STATE VARIABLES FOR ALLOCATION METHODOLOGIES

Description of Variable (Units)
Current employment, SIC 19-39
Current employment, SIC 701 (hotels)
Current employment, SIC 7211, 7216, 7217 (laundries)
Current employment, SIC 806 (hospitals)
Current employment, SIC 821 (schools)
Current employment, SIC 822 (universities)
Current employment, SIC 60 and 70, minus above (other services)
Current employment, SIC 50 (wholesale)
Current employment, SIC 52 (retail)
Current employment, SIC 7215, 2*7216, 7218 (laundries for solvents)
Current employment, SIC 243 (millwork, plywood, etc.)
Current employment, SIC 244 (wooden containers)
Current employment, SIC 371
Current employment, SIC 373
Current employment, SIC 7535
Current employment, SIC 10
Current employment, SIC 16
Current employment, SIC 264
Current employment, SIC 265
Employment data, SIC 19-39 for year of most recent Census of Manufacturers
Employment data, total, 19-39 for year of most recent Census of Manufacturers
Coal consumption data, SIC 19-39 (tons x 10^3)
Coal consumption data, total, 19-39 (tons x 10^3)
Gas consumption data, SIC 19-39 (ft.^{3} x 10^6)
Gas consumption data, total, 19-39 (ft.^{3} x 10^6)
Farms in irrigated areas
Tractors
Combines
Harvesters (corn huskers)
Pickup balers

TABLE 2-3 (continued

STATE VARIABLES FOR ALLOCATION METHODOLOGIES

Description of Variable (Units)
Census year population
Gas-heated dwelling units
Coal-heated dwelling units
Elementary and kindergarten enrollment
High school enrollment
Coal shipments--retail total (10^3 tons)
Coal shipments--retail production district groupings 1-20 (10^3 tons)
Coal shipments--industrial total (10^3 tons)
Coal shipments--industrial production district groupings 1-20 (10^3 tons)
Public school employment
Hotel employee/room ratio
Current population
Percent of gas customers with gas heat (%)
Additions to gas heating, each year since census year
Conversions to gas heating, each year since census year
Gas-heated dwelling units (previous year)
Natural gas consumption, residential ($ft.^3 \times 10^6$)
Natural gas consumption, industrial ($ft.^3 \times 10^6$)
Natural gas consumption, commercial ($ft.^3 \times 10^6$)
Natural gas consumption, other ($ft.^3 \times 10^6$)
LPG consumption, industrial (gallons x 10^3)
LPG consumption, retail (gallons x 10^3)
Anthracite coal shipments, retail (tons)
Bituminous coal shipments, industrial (10^3 tons)
Bituminous coal shipments, retail (10^4 tons)
Anthracite market share (%)
Gasoline consumption, highway (gallons x 10^3)
Gasoline consumption, off-highway (gallons x 10^3)
Gasoline consumption, construction equipment (gallons x 10^3)
Gasoline consumption, commercial-industrial (gallons x 10^3

TABLE 2-3 (continued)
STATE VARIABLES FOR ALLOCATION METHODOLOGIES

Description of Variable (Units)

- Gasoline consumption, agricultural (gallons x 10^3)
- Gasoline consumption, aviation (gallons x 10^3)
- Railroad use of diesel fuel (bbl x 10^3)
- Registrations, motorcycles
- Registrations, snowmobiles
- Registrations, inboard boats
- Registrations, outboard boats
- Census region identifier
- Centroid county snowfall
- Coastline
- Coastline area factor
- Point Source Data:
  - Point source employment, SIC 19-39
  - Point source employment, total, 19-39
  - Point source employment, SIC 701, (724 + 7216 + 7287), 806, 821, 822, other sources, 50, 52, (7215 + 2 x 7216 + 7218), 243, 244, 371, 373, 7535, 10, 16, 264, 265
  - Bituminous coal, commercial consumption (tons)
    - Sulfur content (tons)
    - Ash content (tons)
  - Bituminous coal, industrial consumption (tons)
    - Sulfur content (tons)
    - Ash content (tons)
  - Natural gas consumption, commercial (ft.^{3} x 10^6)
  - Natural gas consumption, industrial (including LPG) (ft.^{3} x 10^6)
  - LPG consumption, commercial (gallons x 10^3)
  - Anthracite coal consumption, commercial (tons)

TABLE 2-4

COUNTY VARIABLES FOR ALLOCATION METHODOLOGIES

Description of Variable (Units)
Degree days
Number of days with temperatures less than 32°F
Number of "warm" months
Snowfall
Current employment, SIC 19-39
Current employment, total, 19-39
Current employment, SIC 701 (hotels)
Current employment, SIC 7211, 7216, 7217 (commercial laundries)
Current employment, SIC 806 (hospitals)
Current employment, SIC 821 (schools)
Current employment, SIC 822 (universities)
Current employment, SIC 60 + 70 minus above 5 other services
Current employment, SIC 50 (wholesale)
Current employment, SIC 52 (retail)
Current employment, SIC 7215 + 2 x 7216 + 7218 (laundries for solvents)
Current employment, SIC 243 (millwork, plywood, etc.)
Current employment, SIC 244 (wooden containers)
Current employment, SIC 371 (motor vehicles and equipment)
Current employment, SIC 373 (ship and boat building and repairing)
Current employment, SIC 7535 (paint stores)
Current employment, SIC 10 (mining)
Current employment, SIC 16 (heavy construction)
Current employment, SIC 264 (miscellaneous connected paper products)
Current employment, SIC 365 (paper board containers and boxes)
Hospital beds
Hospital employment
Public university enrollment
Population density
Kindergarten and elementary school enrollment
High school enrollment

TABLE 2-4 (continued)
COUNTY VARIABLES FOR ALLOCATION METHODOLOGIES

Description of Variable (Units)
Year-round housing units
Median rooms per dwelling unit
% Rooms in 1-unit structures
Farms
Farms with sales greater than or equal to $2500
Census year population
Number of occupied dwelling units
Number of occupied dwelling units with gas heat
Number of occupied dwelling units with LPG heat
Number of occupied dwelling units with oil heat
Number of occupied dwelling units with coal heat
Number of occupied dwelling units with natural gas ranges
Number of occupied dwelling units with LPG ranges
Number of occupied dwelling units with natural gas hot water heaters
Number of occupied dwelling units with LPG hot water heaters
Current population
Tractors
Gross revenues of service stations ($) or retail gasoline consumption (gallons x 10^3)
Air carrier and taxi operations
General aviation operations
Military
Aircraft registrations
Inland water area
Coastline
NEDS Point Source Data:
Point source employment, SIC 19-39
Point source employment, total, 19-39
Point source employment, SIC 701, (7211 + 7216 + 7217), 806, 821, 822, other services, 50, 52, (7215 + 2 x 7216 + 7218), 243, 244, 371, 373, 7535, 10, 16, 264, 265
Point source employment for solvents, SIC 25-27, 30, 34-39

TABLE 2-5

SOURCES REQUIRED FOR INPUT PREPARATION, 1973

	Source	Approximate Date Available	Application	Cost	Availability
1.	Coal - Bituminous and Lignite, Annual (preprint), Bureau of Mines, Washington, DC 20240	Early January 1975	Sulfur & Ash	Free	Leonard W. Westerstrom Division of Fossil Fuels, (703) 557-1350
2.	Analysis of Tipple and Delivered Samples of Coal, Bureau of Mines, Washington, DC (Report of Investigations Series)	1973-1974	Sulfur & Ash	$ 0.50	U.S. Government Printing Office, Washington, DC 20402
3.	Keystone Coal Industry, McGraw-Hill, Inc.		Sulfur & Ash	$60.00	Mining Information Service, McGraw-Hill, New York, NY
4.	Use of Gas by Residential Appliances. American Gas Association, Arlington, VA	Quintennial (Most Recent 1972)	Residential LPG	Free	Robert Griffiths, Statistics Department, (703) 524-2000, X348
5.	Motorcycle Usage and Owner Profile Study, prepared for Motorcycle Industry Council	Annual	Off-Highway		Hendrix Tucker Walker, 7447 North Figurroa Street, Los Angeles, CA 90041 (213) 254-9217
6.	Petroleum Statement, Annual (final summary), U.S. Bureau of Mines, Washington, DC 20240	February, 1975	Solvents	Free	Betty M. Moore, Division of Fossil Fuels, (703) 557-1667
7.	Synthetic Organic Chemicals, U.S. Production and Sales, U.S. International Trade Commission, Washington, DC 20436	Late 1975	Solvents	$ 2.40	Chemicals Division, (202) 523-0387

TABLE 2-5 (continued)

SOURCES REQUIRED FOR INPUT PREPARATION, 1973

Source	Approximate Date Available	Application	Cost	Availability
8. Fuels and Electric Energy Consumed, Census of Manufactures, U.S. Bureau of the Census, Washington, DC 20233	Quintennial (Most recent 1972)	Industrial		Arthur Horowitz, (301) 763-7666
9. County Business Patterns, U.S. Bureau of the Census, Washington, DC 20233	Annual	Industrial	$100.00	U.S. Government Printing Office, Washington, DC 20402
10. Statistical Abstract of the United States, U.S. Bureau of the Census, Washington, DC 20233	Annual	Off-Highway	$ 6.30	U.S. Government Printing Office, Washington, DC 20402
11. Natural Gas Production and Consumption, U.S. Bureau of Mines, Washington, DC 20240	August 1974	Residential, Commercial, Industrial	Free	Leonard L. Fanelli, Division of Fossil Fuels, (703) 557-1454
12. Bituminous Coal and Lignite Distribution (annual), U.S. Bureau of Mines, Washington, DC 20240	April 1974	Sulfur & Ash	Free	Leonard W. Westerstrom, Division of Fossil Fuels, (703) 557-1350
13. Fall 1973 Statistics of Public School Systems, U.S. Department of Health, Education, and Welfare, Washington, DC	1975	Commercial		U.S. Office of Education, Department of Health, Education, and Welfare
14. Statistics of State School Systems, 1969-1970, U.S. Department of Health, Education and Welfare, Washington, DC	1973	Commercial		U.S. Office of Education, Department of Health, Education and Welfare

TABLE 2-5 (continued)

SOURCES REQUIRED FOR INPUT PREPARATION, 1973

Source	Approximate Date Available	Application	Cost	Availability
15. Subject Reports, U.S. Census of Selected Services, U.S. Bureau of the Census, Washington, DC	Quintennial (Most recent 1967)	Commercial		U.S. Government Printing Office, Washington, DC
16. Population Estimates (Series P-26), U.S. Bureau of the Census, Washington DC	Annual	Residential, Solvents, Off-Highway, Railroads	$30.00	U.S. Government Printing Office, Washington, DC
17. Gas House Heating Survey, Department of Statistics, American Gas Association, Arlington, VA 22209	1974	Residential	Free	Robert Griffith, Department of Statistics, (703) 524-2000
18. Sales of Liquified Petroleum Gas and Ethane, U.S. Bureau of Mines, Washington, DC	September 1975	Residential, Commercial, Industrial	Free	Leonard L. Fanelli, Division of Fossil Fuels, (703) 557-1454
19. Distribution of Pennsylvania Anthracite for the Calendar Year, U.S. Bureau of Mines, Washington, DC	December 1974	Residential, Commercial	Free	Dorothy R. Federoff, Division of Fossil Fuels, (703) 557-3562
20. Highway Statistics, Federal Highway Administration, Washington, DC	1975	Retail Sales of Gasoline	$ 3.20	L. French, (202) 426-0180
21. Sales of Fuel Oil and Kerosene, U.S. Bureau of Mines, Washington, DC	September 1974	Railroads	Free	James M. Diehl, Division of Fossil Fuels, (703) 557-0443

TABLE 2-5 (continued)

SOURCES REQUIRED FOR INPUT PREPARATION, 1973

Source	Approximate Date Available	Application	Cost	Availability
22. The Marine Market, 1972, Marex (International Marine Expositions, Inc.), Chicago, IL.	April 1973	Off-Highway		
23. Boating 1972, Marex and National Association of Engine and Boat Manufacturers				
24. Census of Agriculture, U.S. Bureau of the Census, Washington, DC	Quintennial (Most recent 1972)	Off-Highway		U.S. Government Printing Office, Washington, DC
25. AHA Guide to the Health Care Field, American Hospital Association, Chicago, IL	Annual	Commercial		John A. Henderson, Director of Marketing Services, (312) 645-9400
26. The College Blue Book, MacMillan Information, New York, NY	Annual	Commercial	~$10.00	MacMillan Publishing Company, Inc., 866 Third Avenue, New York, NY 10022
27. Census of Retail Trade, Area Statistics	Quintennial (Most recent 1972)	Retail Sales	~$100.00	U.S. Government Publishing Office, Washington, DC
28. FAA Air Traffic Activity, Federal Aviation Administration, Washington, DC	February 1974	LTOs	$4.55	U.S. Government Printing Office, Washington, DC

TABLE 2-5 (continued)

SOURCES REQUIRED FOR INPUT PREPARATION, 1973

Source	Approximate Date Available	Application	Cost	Availability
29. Military Air Traffic Activity Report, Federal Aviation Administration, Washington, DC	1974	LTOs	Free	Betty Cayce, Office of Management Systems, (202)
30. Census of U.S. Civil Aircraft, Federal Aviation Administration, Washington, DC	1975	LTOs	$2.85	U.S. Government Printing Office, Washington, DC
31. Area Measurement Reports, U.S. Bureau of the Census, Washington, DC	1970	Off-Highway	$0.25	U.S. Government Printing Office, Washington, DC

TABLE 2-6
CONTACTS FOR RETAIL SALES OF GASOLINE DATA

State	Contact
Arizona	Mr. Dave Tweedie Gas Tax Auditor 1739 W. Jackson Pheonix, Arizona 85007
Florida	State of Florida Gas Bureau Department of Revenue Tallahassee, Florida (904) 488-7417
Georgia	Curtis B. Modling, Director Motor Fuel Tax Unit Department of Revenue 318 Trinity Washington Building Atlanta, Georgia 30334
Louisiana	Richard L. Clousing, Supervisor Special Fuels Tax Unit Department of Revenue P.O. Box 201 Baton Rouge, Louisiana 70821 (504) 389-6223
Minnesota	James F. Dagen, Director Petroleum Division Minnesota Department of Taxation Centennial Office Building Saint Paul, Minnesota 55101
New Mexico	C. Tampin Bureau of Revenue State of New Mexico Baatan Memorial Building Santa Fe, New Mexico 87501

TABLE 2-7
MAGNETIC TAPES REQUIREMENTS

Name and Source	Frequency	Cost	Contact
County and City Data Book Tape U.S. Bureau of the Census	Quintennial Latest: 1972	$ 70	Helen Tier (301) 763-5475
County Business Patterns U.S. Bureau of the Census	Annual	$580	Mr. Schieldal
Census of Housing and Population U.S. Bureau of the Census	Decennial	$500	
1009 Name Tape National Oceanic and Atmospheric Administration	Annual	$ 60	Mr. Norton (704) 254-0961
Monthly Climatological Data National Oceanic and Atmospheric Administration	Annual	$ 60	Mr. Norton (704) 254-0961
Point Source Fuel Consumption	Annual	--	NADB
Point Source Employment	Annual	--	NADB
CBP-SAROAD NOAA-SAROAD GSA-SAROAD	Geographic code index tapes		NADB

III. DEVELOPMENT OF METHODOLOGIES

A. RESIDENTIAL

Development of the methodology for allocation of statewide residential fuel use within counties is described in this section for each of three primary fuels: natural gas, LPG, and coal.

1. Natural Gas

a. Regression Analysis

An algorithm was developed from regression analysis for estimating county consumption of natural gas by residential sources. The assumption was made in the analysis that natural gas consumption by residential users is a function of climatological and housing stock descriptive variables. The data sample was obtained from a number of gas companies which distribute gas to about 1,000 communities. Screening the data for completeness reduced the sample size to approximately 300 communities. The candidate independent variables considered for inclusion in the regression equation were annual degree days, average wind speed in January, number of dwelling units using gas for space heating, number of dwelling units using gas for water heating, number of dwelling units using gas for cooking, percent of dwelling units in structures built after 1960, number of rooms per dwelling unit, percent of dwelling units in single-unit structures, percent of annual growth of gas-heated dwelling units in the state, latitude, and average elevation. Details of the regression analysis results are given in Appendix A.

The resultant algorithm relating natural gas consumption to the most significant regressors is expressed as

$$\ell n(T) = 3.57 + 0.367\ \ell n(D) + 0.588\ \ell n\left(\frac{U_{gh}}{U_x}\right) + 0.125\ \ell n(R_d)$$

where ℓn = log to the base e

T = gas consumption per dwelling unit (therms)

D = annual degree days [3]

U_{gh} = number of dwelling units using gas for space heating [4]

U_x = the larger of the number of dwelling units using gas for cooking or for heating water [4]

R_d = median number of rooms per dwelling unit [5]

The composite variable U_{gh}/U_x is used to reflect the variation in energy consumption per dwelling unit between communities with similar climates, but with different percentages of gas customers using gas for space heating.

The total residential consumption of natural gas for a county is calculated as follows:

$$NG_c = 9.69 \times 10^{-5} T_{ng} U_g$$

where NG_c = county residential consumption of natural gas (10^6 cu. ft.)

9.69×10^{-5} = factor to convert heat equivalent of gas to 10^6 cu. ft.

U_g = total number of dwellings in county that use gas

The total number of dwelling units in the county that use gas is calculated from the number of occupied dwelling units using gas for space heating and the fraction of statewide residential gas customers using gas for heating, viz.,

$$U_g = \frac{1}{f} U_{gh}$$

where U_g = number of occupied dwelling units in the county using gas

f = fraction of statewide residential gas customers with gas heat [30]

b. Updating the Housing Stock Data

If the year of interest corresponds to the decennial census, the number of dwelling units using gas for space heating is reported directly [4]. A method of updating this variable during intervening years was developed. This procedure is illustrated by the following example:

$$U'_{gh} = U_{gh} + \Delta U_{gh}$$

$$\Delta U_{gh} = \left(\frac{\Delta P_c}{\Delta P_s}\right) A + \left(\frac{U_{gh}}{U_s}\right) C$$

where U'_{gh} = number of dwelling units using gas for space heating in the year of interest

U_{gh} = number of dwelling units using gas for space heating in the census year [4]

ΔU_{gh} = total increase since the census year (1970) in dwelling units using gas for space heating

ΔP_c = increase in county population since the census year (0 if there was a decrease or no change in population)

$$P_s = \sum_c P_c$$

A = number of additional gas-heated dwelling units in the state due to new housing starts since the census year [30]

C = number of conversions to gas space heating in the state since the census year [30]

U_s = statewide number of dwelling units using gas for space heating in the census year [4]

An alternate method for distribution of statewide additions of gas-heated dwelling units was investigated using housing authorized by building permits [31]. At the time of this study, the Construction Statistics Division of the Census Bureau does not compile these data for all areas of the country on a routine basis, and so this alternative was abandoned.

The composite housing stock variable U_{gh}/U_x and the median number of rooms per dwelling unit are not updated for years intervening between census years. That is, the value of U_{gh} used in the composite housing stock variable is the census year number of housing units using gas for space heating.

c. Normalization

Estimates of county residential natural gas consumption are normalized against the state total published in the Mineral Industry Survey (M.I.S.): Natural Gas Production and Consumption [6].

$$NG_c' = \frac{NG_c}{NG_s} X_s$$

where NG_c' = normalized county residential consumption of natural gas (10^6 cu. ft.)

NG_c = unnormalized county residential consumption of natural gas

$NG_s = \sum_c NG_c$

X_s = published state total residential consumption of natural gas (10^6 cu. ft.) [6]

Because this normalization apportions the published state total to counties according to the ratio of calculated consumption for individual counties to total calculated county consumption in the state, the conversion of the estimated county consumption in therms to the gas equivalent in 10^6 cu. ft. is not necessary.

2. LPG

The algorithm for estimating countywide natural gas consumption is considered inappropriate for LPG application, due to limitations in the available data. For example, the variable median rooms per dwelling unit is reported only for the whole county and is not cross-tabulated by fuel type; the small percentage of the housing stock using LPG argues against using this countywide figure. Also, it would be difficult to interpret and apply the composite housing variable for gas, U_{gh}/U_x, to LPG. Consequently, a simpler estimation procedure was developed based on energy consumption statistics compiled by the American Gas Association (AGA).

Central heating load, expressed as a function of degree days, has been compiled by the AGA [7] for the entire country and is reproduced in

Table 3-1. Using the data for the average load category, the following algorithm for computing energy consumption per dwelling unit was formulated:

$$T_h = 376 + 0.209\ D$$

where T_h = energy consumption for space heating (therms per dwelling unit)

D = annual degree days

Cooking and water heating requirements are added to this space heating component to account for total residential demand. The formula for computing county residential LPG consumption is

$$T_\ell = (376 + 0.209\ D)\ U_{\ell h} + \bar{c}_w U_{w} + \bar{c}_r U_{\ell r}$$

where T_ℓ = county residential consumption of LPG (therms)

D = annual degree days

$U_{\ell h}$ = number of occupied dwelling units in the county that use LPG for space heating [4]

$\bar{c}_w$ = regional average consumption by hot water heating (therms/unit) [7]

$U_{\ell w}$ = number of occupied dwelling units in the county that use LPG for heating water [4]

$\bar{c}_r$ = regional average consumption by cooking ranges (therms/unit) [7]

$U_{\ell r}$ = number of occupied dwelling units in the county that use LPG for cooking [4]

LPG consumption is converted to 10^3 gallons by the expression

$$LPG_c = 0.00105\ T_\ell$$

where 0.00105 = the factor to convert heat equivalent of LPG to 10^3 gallons (10^3 gallons/therm)

The number of occupied dwelling units in each county is available from the census of housing report for the most recent census year [4]. These data are not updated for the intervening years between census years. Regional average consumption per dwelling unit for cooking and water heating purposes is derived from data compiled by the AGA on average consumption by residential

TABLE 3-1

CENTRAL HEATING LOAD BY HEATING DEGREE DAYS*

(Therms per Year)

Mean Seasonal Degree Days	Minimum Load	Average Load	Maximum Load
0	70	376	500
500	155	480	612
1,000	240	585	725
1,500	325	689	837
2,000	410	794	950
2,500	495	899	1,062
3,000	580	1,004	1,175
3,500	665	1,109	1,287
4,000	750	1,213	1,400
4,500	835	1,318	1,512
5,000	920	1,422	1,625
5,500	1,005	1,527	1,737
6,000	1,090	1,631	1,850
6,500	1,175	1,736	1,962
7,000	1,260	1,840	2,075
7,500	1,345	1,945	2,187
8,000	1,430	2,049	2,300
8,500	1,515	2,154	2,412
9,000	1,600	2,258	2,525
9,500	1,685	2,363	2,637
10,000	1,770	2,467	2,750

This table was computed from actual househeating load studies and load estimates of 74 companies located across the United States during 1971.

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* Source: American Gas Association, Department of Statistics

appliances. The appropriate statistics are from columns 3 and 5 of Table 3-2.

State residential consumption of LPG is not published, but retail (commercial and residential) consumption of LPG is [8]. If the sum of the county LPG consumption estimates exceeds the published state total, the county figures are normalized against the published total. Otherwise, the county estimates are left unchanged, and the remainder of the published state retail consumption of LPG is used as the commercial consumption figure for the state.

3. Coal

The basic approach taken in developing methodologies for allocation of residential consumption of anthracite and bituminous coal to individual counties was to establish a functional relationship between coal consumption per dwelling unit and degree days, to adjust housing data for secular trends in the number of coal-heated dwelling units, and to disaggregate the total coal consumption into anthracite and bituminous components and normalize the results as necessary.

a. Development of a Relationship between Coal Consumption and Degree Days

Four approaches were investigated in the search for an acceptable expression for residential coal consumption in terms of degree days.

(1) The first approach was modeled after the approach used in developing the methodology for allocation of residential LPG. The method is based on the average central heating load data compiled by AGA [7]. Residential cooking and water heating uses of coal, however, are assumed to be negligible and are, therefore, excluded from the algorithm. To correct for the lower efficiency of coal in relation to gas in space heating systems, a factor for inflating the therm requirement for space heating by coal was needed. A factor of 1.33 was derived from the information published by the Independent Natural Gas Association of America [32] (reproduced in Table 3-3)

TABLE 3-2

USE OF GAS BY RESIDENTIAL APPLIANCES

(Average Consumption, Excluding Extremes)
(Therms per Year)

	1971 Residential Customers	House Range	Apt. Range	Water Heater	Clothes Dryer (Gas Pilot)	Clothes Dryer (Elec. Pilot)	Incinerator	Gas Light	Air Conditioner Consumption Per Ton	Gas Grill	Gas Heat All Types
United States											
1971 Survey	23,511,693	105	88	316	75	60	130	181	283	26	1,192
1966 Survey	27,027,000	106	74	274	90	52	138	183	308	29	NA
New England											
1971 Survey	1,208,248	101	84	242	92	76	130	155	216	33	1,462
1966 Survey	NA	101	72	245	91	49	156	195	209	29	NA
Middle Atlantic											
1971 Survey	4,623,211	117	81	318	65	65	119	174	226	28	1,313
1966 Survey	NA	102	71	282	90	52	143	177	193	24	NA
East North Central											
1971 Survey	6,578,977	101	90	317	69	58	147	192	200	23	1,539
1966 Survey	NA	105	64	288	88	46	144	189	236	23	NA
West North Central											
1971 Survey	1,717,732	87	69	341	75	52	139	157	269	17	1,178
1966 Survey	NA	101	67	273	86	53	134	175	284	33	NA
South Atlantic											
1971 Survey	1,969,491	95	77	358	66	40	158	202	252	32	1,022
1966 Survey	NA	91	72	241	89	49	132	187	443	31	NA
East South Central											
1971 Survey	807,061	127	92	287	60	63	116	196	343	33	865
1966 Survey	NA	119	107	295	74	60	114	174	361	22	NA
West South Central											
1971 Survey	2,661,538	112	106	319	83	63	162	179	465	35	660
1966 Survey	NA	122	84	236	84	56	96	186	479	42	NA

TABLE 3-2 (continued)

USE OF GAS BY RESIDENTIAL APPLIANCES

(Average Consumption, Excluding Extremes)
(Therms per Year)

	1971 Residential Customers	House Range	Apt. Range	Water Heater	Clothes Dryer (Gas Pilot)	Clothes Dryer (Elec. Pilot)	Incinerator	Gas Light	Air Conditioner Consumption Per Ton	Gas Grill	Gas Heat All Types
Mountain											
1971 Survey	1,104,700	103	86	261	120	77	150	179	261	28	1,079
1966 Survey	NA	111	73	319	107	65	136	180	399	26	NA
Pacific											
1971 Survey	2,840,735	102	96	329	80	54	171	178	249	16	841
1966 Survey	NA	118	89	278	96	46	160	188	264	34	NA

Note: A total of 157 companies with a total of 23,511,693 residential customers provided data for this summary. This represents 60 percent of the 39,194,000 residential customers in the United States (1971).

Source: American Gas Association, Department of Statistics, February 1973

TABLE 3-3

SINGLE-FAMILY DWELLING UNIT THERMAL EFFICIENCIES OF GAS AND COAL

	Gas	Coal
Baltimore, Maryland	80	55
Boise, Idaho	75	65
Brooklyn, New York	70	50
Cambridge, Massachusetts	75	60
Charlestown, South Carolina	80	55
Chicago, Illinois	75	50
Cleveland, Ohio	70	50
Danville, Virginia	80	60
Davenport, Iowa	75	60
Denver, Colorado	75	60
Des Moines, Iowa	80	55
Detroit, Michigan	75	55
Erie, Pennsylvania	70	50
Fort Wayne, Indiana	75	60
Grand Rapids, Michigan	72	60
Indianapolis, Indiana	75	50
Kansas City, Missouri	75	55
Louisville, Kentucky	75	50
Lowell, Massachusetts	75	60
Madison, Wisconsin	80	55
Memphis, Tennessee	60	50
Milwaukee, Wisconsin	75	60
Missoula, Montana	75	61.4
Nashville, Tennessee	70	60
Oklahoma City, Oklahoma	80	54
Peoria, Illinois	80	60
Providence, Rhode Island	75	55
Pueblo, Colorado	75	60
Richmond, Virginia	80	60
Rochester, New York	80	65
Salt Lake City, Utah	80	65
St. Louis, Missouri	71	57
St. Paul, Minnesota	75	60
Seattle and Tacoma, Washington	75	62
Shelby, North Carolina	80	45
Southeast, Michigan	75	60
Spokane, Washington	75-78	55-60
Topeka, Kansas	80	60
Tulsa, Oklahoma	80	54

by taking the average of the ratios of gas thermal efficiency to coal thermal efficiency. With these adjustments, the resulting residential coal consumption formula becomes:

$$C = 1.33 * (0.209\ D + 376)\ U_{coal} * h \qquad \text{(i)}$$

where C = county consumption of residential coal (therms)

D = annual degree days [3]

U_{coal} = number of occupied dwelling units using coal for space heating [4]

h = 0.00387 (factor to convert consumption from heat equivalent in therms to coal in tons)

Comparison of this coal consumption formula with the recent EPA method [18] represented by

$$C = 0.0012 * D * U_{coal} \qquad \text{(ii)}$$

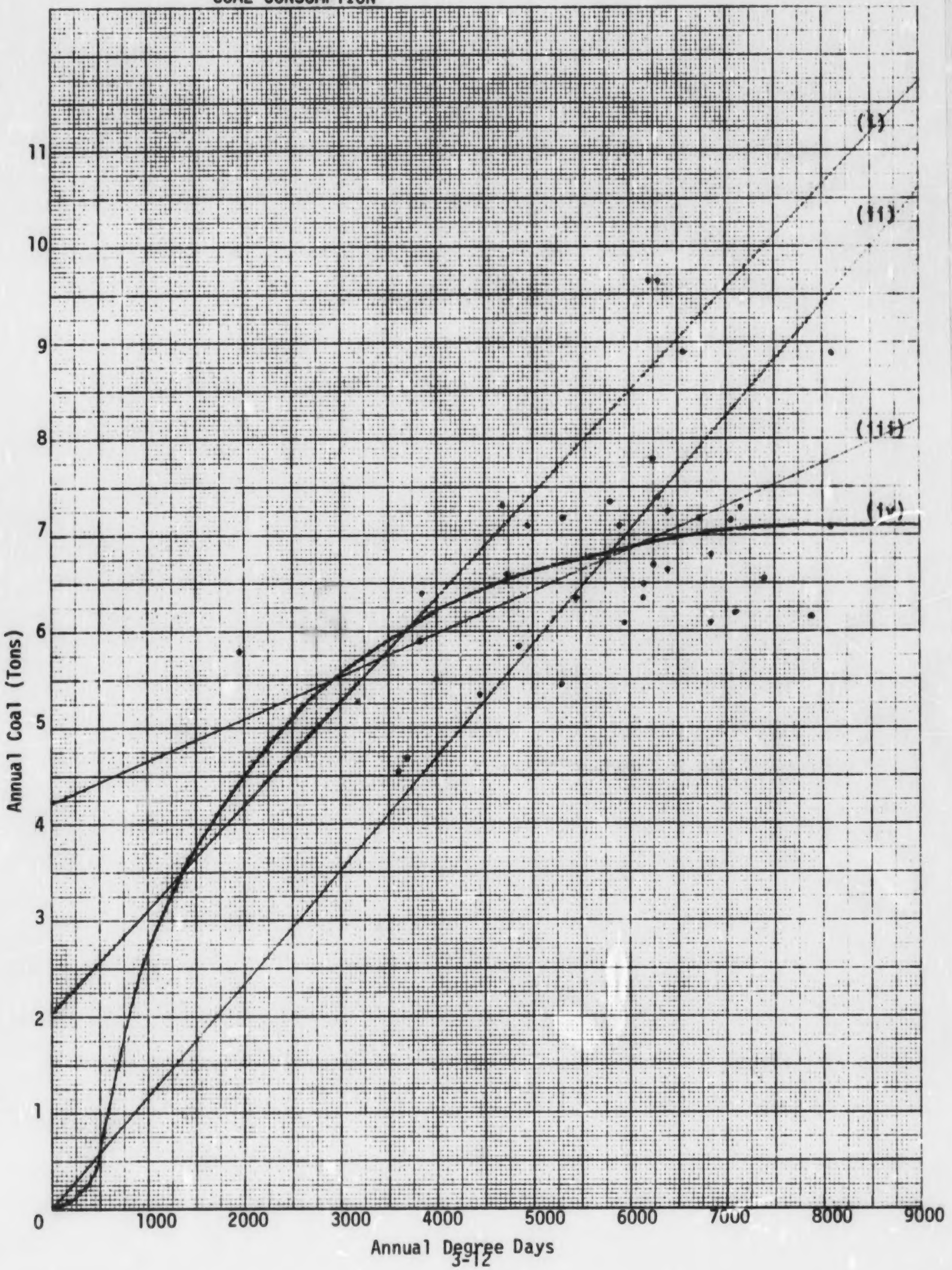
showed that method (i) produces higher estimates than the EPA's. The unavailability of actual consumption data for coal-heated dwelling units imposed a constraint on any effort to test the reliability of either equation.

(2) The second method for estimating coal consumption is based on data from a 1971 survey conducted by the Independent Natural Gas Association of America (INGAA). The INGAA requested from local gas companies the average coal, oil, electricity, and gas consumption for a typical house in 64 cities [32]. Coal figures were reported for 38 cities. According to the INGAA, these figures represent actual consumption data obtained from local coal dealers by the gas distribution company in each city. A plot of these data points and a regression line (labeled (iii)) are shown in Figure 3-1. The equation for the line, expressed as

$$C = 4.15 + 0.00044 * D * U_{coal} \qquad \text{(iii)}$$

indicates a markedly lower slope for coal consumption than either method (i) or the EPA formula (labeled (i) and (ii) in Figure 3-1, respectively). Since the INGAA equation was developed from actual coal consumption data,

FIGURE 3-1. COMPARISON OF FOUR CANDIDATE EQUATIONS FOR AVERAGE RESIDENTIAL COAL CONSUMPTION



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it is considered to provide closer approximation of coal consumption than the other two formulas for areas with annual degree days above 3,000. However, due to the lack of data for areas in the lower degree day range, the INGAA equation is considered unreliable for counties with annual degree days below 3,000.

By performing a regression on the INGAA data, but imposing the constraint of a zero intercept (i.e., no coal consumption in areas with zero degree days), and using a reciprocal logarithmic transformation of the form

$$\ln y = \alpha - \beta \left(\frac{1}{x}\right)$$

a formula that is more realistic for areas with low degree days was obtained:

$$C = e^{\left(2.13 - \frac{1,280}{D}\right)} \qquad \text{(iv)}$$

However, this formula, labeled (iv) in Figure 3-1, yielded a rather unsatisfactory coefficient of determination (R^2) of 0.267, which prompted further efforts to resolve the unexplained variation.

(3) The third method involved the specification of additional regressors. Two dichotomous variables and three housing variables were used. One of the dichotomous variables was assigned a value of 1 or 0, depending on the type of coal. This variable was included to test for a different pattern of consumption for anthracite; it was expected to be uncorrelated with consumption. The second dichotomous variable was assigned a value of 1 for hand-fored and 0 for stoker-fired. This variable was expected to be positively correlated with consumption.

The housing variables used were percentage of dwelling units in single-family structures, the median number of rooms per dwelling unit, and the percentage of dwelling units in structures built before 1950. For the purpose of this analysis, it was necessary to use statistics that reflect the characteristics of the entire housing stock, because the required data were not disaggregated by type of fuel [4]. All three variables are expected to be positively correlated to consumption.

There was no statistically significant relationship found between consumption and the variable related to type of coal. With the exception of the variable related to percentage of dwelling units built before 1950, the other two housing variables an the variable related to stoking method had negative regression coefficients and a confidence interval that included zero. Our a priori assumption for positive correlation with consumption was, therefore, not supported by the analysis results for all but one variable. The inclusion of the percentage of dwelling units in structures built before 1950 produced the following results:

$$C = 0.00387 \left[7.81 - 13\left(\frac{1}{p}\right) - 842\left(\frac{1}{D}\right)\right]$$

where C = coal consumption per dwelling unit (tons)

p = percentage of dwelling units built before 1950 [4]

D = annual degree days

0.00387 = factor to convert consumption from heat equivalent in therms to coal in tons

The t-statistics for the coefficients of $\left(\frac{1}{p}\right)$ and $\left(\frac{1}{D}\right)$ are 1.79 and 3.05, respectively; they are both above the 95% one-tailed critical value of 1.69, allowing the rejection of the null hypothesis of the coefficient equaling zero. The inclusion of this housing variable raised the R^2 from 0.287 to 0.350. The R^2 corrected for the number of degrees of freedom increased from 0.260 to 0.310.

(4) Analysis for variation in the heating value of coal. Variation in reported BTU content of coal ranges from 1.0×10^4 to 1.5×10^4 BTU/lb. A regression relating coal consumption in therms to degree days and percentage of dwelling units built before 1950 resulted in the equation

$$\ell n\,(T_{du}) = 7.64 - 1000 * \left(\frac{1}{D}\right)$$

where T_{du} = coal consumption per dwelling unit in therms

This transforms to the equation

$$T_{du} = 0.00387\ e^{\left(7.64 - \frac{1000}{D}\right)} \qquad \text{(v)}$$

The t-statistic for the coefficient of $\frac{1}{D}$ is 3.7; the R^2 is 0.287; and the corrected R^2 is 0.266. The generally poor R^2 is attributed to the coal data in the sample. While the inclusion of the percentage of dwelling units in structures built before 1950 did improve the R^2, the improvement was slight and, therefore, did not warrant the expenditure of the extra effort associated with its inclusion. Equation (v) was selected for county allocation purposes. The formula for total county residential coal consumption derived from this equation is

$$C = 0.00387\ T\ U_{coal}\ e^{\left(7.64 - \frac{1000}{D}\right)} \qquad \text{(vi)}$$

b. Disaggregation of Coal Consumption into Anthracite and Bituminous Components

Total county residential consumption of coal is disaggregated into bituminous and anthracite using a state anthracite market share factor:

$$a_c = f_a * C$$

$$b_c = (1 - f_a) * C$$

where a_c = estimated county residential anthracite coal consumption (tons)

b_c = estimated county residential bituminous coal consumption (tons)

C = estimated total county residential coal consumption (tons)

f_a = fraction of total state coal market that is anthracite

Appendix C contains an explanation of the development of the anthracite market share factor.

c. Adjustment for Secular Trend in Number of Coal-Heated Dwelling Units

Annual Bureau of the Census estimates for the number of coal-heated dwelling units will not be available until after 1975 [33]. Until the release of these figures, the secular trend of retail will be used to adjust the 1970 Census of Housing coal-heated dwelling unit data [34].

Time series regression analysis of the annual retail coal shipments [56] for the period 1950-1972, with a lagged dependent variable, yielded the following results:

$$S_y = -150.6 + 0.942 * S_{y-1} \qquad \text{(vii)}$$

where S_y and S_{y-1} = annual retail coal shipments (10^3 tons) for years y and y-1, respectively

The R^2 is 0.918 and is judged to be acceptable for time-series application. To test for the possible violation of the assumption of an uncorrelated error term, the Durbin-Watson statistic was calculated to test the hypothesis of a non-autocorrelated error term. The resulting value of 2.037 does not allow the rejection of this hypothesis at the 1% level. Equation (vii) is used to estimate the decline in coal-heated housing stock. Neglecting the intercept, the number of dwelling units heated by coal in any given year in this decade is given by

$$U_{coal,197x} = 0.942^x \, U_{coal,1970}$$

where x = the last digit of the year (e.g., x = 3 for 1973)

$U_{coal,1970}$ = number of occupied dwelling units in 1970 using coal for space heating [4]

d. Normalization

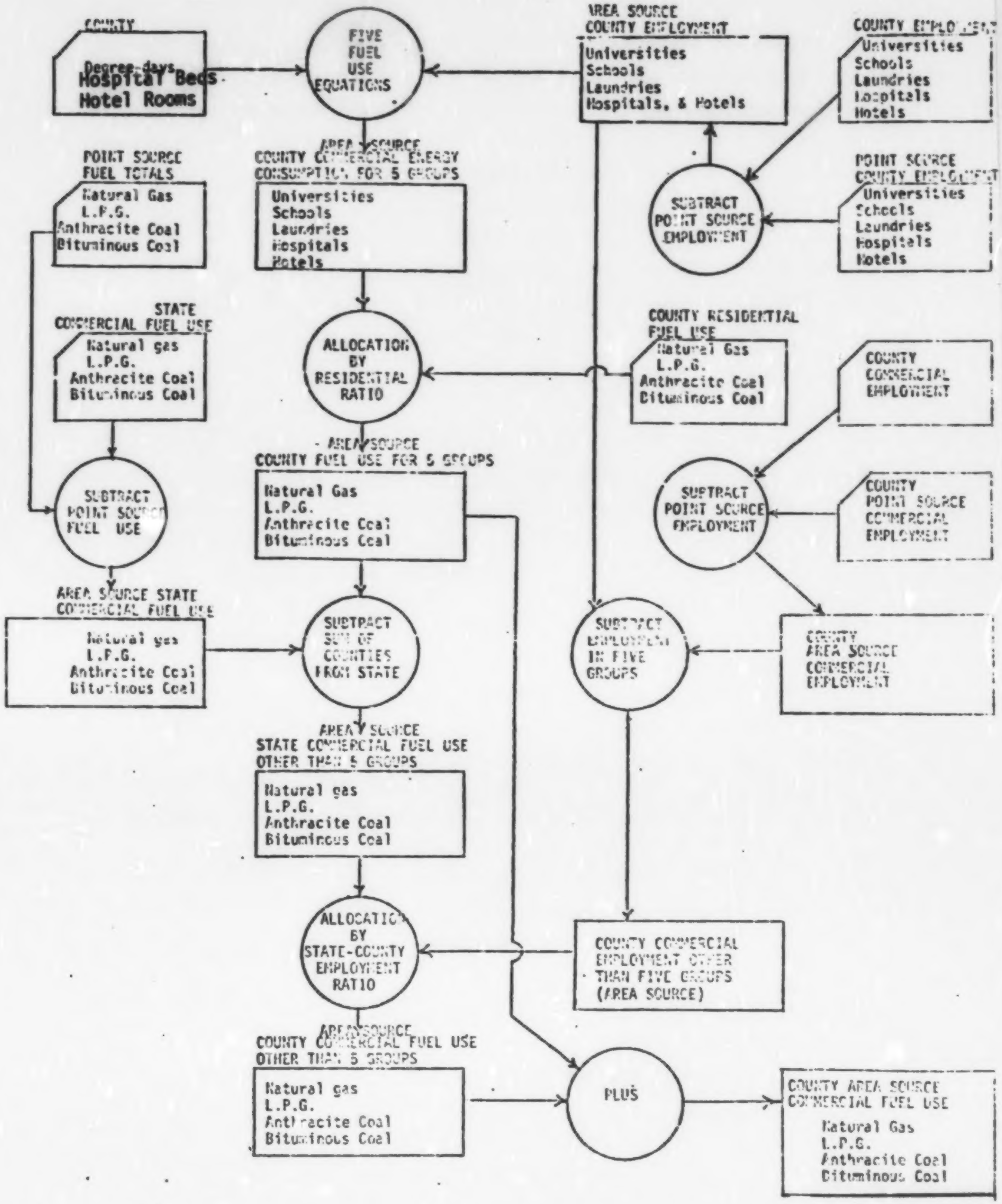
It was assumed that retail coal is used primarily by residential sources. Therefore, all estimated residential is divided between anthracite and bituminous coal types before allotting any remaining retail coal to commercial users. It was decided that, if estimates of one coal type exceed the published state total, the excess represents consumption of the other coal type by residential users. Thus, the excess is distributed to the other coal type by county according to the distribution of existing consumption estimates of that coal type. If, after any adjustments, estimated consumption of either coal type still exceeds the published total, the county consumption is normalized against the state total. The procedure for the adjustment and normalization of residential coal consumption is given in Section II.A.1.c.

B. COMMERCIAL-INSTITUTIONAL

Area source consumption of fuel by commercial and institutional sources consists of all fuel burned in stationary sources which is not included under the residential sources, industrial sources, power plants, or commercial point sources. Statewide commercial area source consumption of natural gas, LPG, anthracite coal, and bituminous coal is determined by subtracting consumption by point sources in the state from published state consumption totals of corresponding fuel type. The methodology developed for allocating state commercial area source fuel consumption to individual counties is summarized by the flow diagram in Figure 3-2. The five basic steps in the methodology for allocation of commercial area source fuel consumption are:

- Determining actual state commercial area source consumption of each fuel type
- Estimating total fuel used by five major commercial-institutional subcategories, namely hospitals, hotels, universities, schools, and commercial laundries
- Apportioning the total fuel used by the five subcategories among the four fuel types
- Determining normalization factors and statewide fuel use by all commercial institutions and services other than the five major subcategories
- Apportioning state consumption of each fuel by these "other" commercial categories and adding it to the corresponding five subcategory consumption.

FIGURE 3-2. Commercial Allocation Methodology


COUNTY
Degree-days
Hospital Beds
Hotel Rooms
FIVE FUEL USE EQUATIONS
AREA SOURCE COUNTY EMPLOYMENT
Universities
Schools
Laundries
Hospitals, & Hotels
COUNTY EMPLOYMENT
Universities
Schools
Laundries
Hospitals
Hotels
POINT SOURCE FUEL TOTALS
Natural Gas
L.P.G.
Anthracite Coal
Bituminous Coal
AREA SOURCE COUNTY COMMERCIAL ENERGY CONSUMPTION FOR 5 GROUPS
Universities
Schools
Laundries
Hospitals
Hotels
SUBTRACT POINT SOURCE EMPLOYMENT
POINT SOURCE COUNTY EMPLOYMENT
Universities
Schools
Laundries
Hospitals
Hotels
STATE COMMERCIAL FUEL USE
Natural gas
L.P.G.
Anthracite Coal
Bituminous Coal
ALLOCATION BY RESIDENTIAL RATIO
COUNTY RESIDENTIAL FUEL USE
Natural Gas
L.P.G.
Anthracite Coal
Bituminous Coal
COUNTY COMMERCIAL EMPLOYMENT
SUBTRACT POINT SOURCE FUEL USE
AREA SOURCE COUNTY FUEL USE FOR 5 GROUPS
Natural Gas
L.P.G.
Anthracite Coal
Bituminous Coal
SUBTRACT POINT SOURCE EMPLOYMENT
COUNTY POINT SOURCE COMMERCIAL EMPLOYMENT
AREA SOURCE STATE COMMERCIAL FUEL USE
Natural gas
L.P.G.
Anthracite Coal
Bituminous Coal
SUBTRACT SUM OF COUNTIES FROM STATE
SUBTRACT EMPLOYMENT IN FIVE GROUPS
COUNTY AREA SOURCE COMMERCIAL EMPLOYMENT
AREA SOURCE STATE COMMERCIAL FUEL USE OTHER THAN 5 GROUPS
Natural gas
L.P.G.
Anthracite Coal
Bituminous Coal
ALLOCATION BY STATE-COUNTY EMPLOYMENT RATIO
COUNTY COMMERCIAL EMPLOYMENT OTHER THAN FIVE GROUPS (AREA SOURCE)
AREA SOURCE COUNTY COMMERCIAL FUEL USE OTHER THAN 5 GROUPS
Natural gas
L.P.G.
Anthracite Coal
Bituminous Coal
PLUS
COUNTY AREA SOURCE COMMERCIAL FUEL USE
Natural Gas
L.P.G.
Anthracite Coal
Bituminous Coal

1. Determining State Commercial Area Source Fuel Consumption

$$X_1 = G_1 + G_2 - G_p$$

$$X_2 = L - (L_r + L_p)$$

$$X_3 = A - (A_r + A_p)$$

$$X_4 = B - (B_r + B_p)$$

where X_1 = state commercial area source consumption of natural gas

X_2 = state commercial area source consumption of LPG

X_3 = state commercial area source consumption of anthracite coal

X_4 = state commercial area source consumption of bituminous coal

G_1 = statewide sales of natural gas for commercial use [6]

G_2 = other gas sales [6]

G_p = natural gas consumption by commercial-institutional point sources

L = statewide retail sales of LPG [8]

L_r = computed state consumption of LPG by residential sources

L_p = LPG consumption by commercial-institutional point sources

A = shipments of anthracite coal to the state [9]

A_r = computed state consumption of anthracite coal by residential sources

A_p = anthracite coal consumption by all point sources

B = adjusted shipments of bituminous coal to retail dealers

B_r = computed state consumption of bituminous coal by residential sources

B_p = bituminous coal consumption by commercial-institutional sources

2. Estimating Total Fuel Consumed by Five Commercial Subcategories

The five major commercial subcategories were defined as hospitals, hotels, universities, schools, and commercial laundries. Regression analyses were performed for each of these subcategories to determine any linear correlation between fuel consumption and degree days, employment within each category, and other independent variables peculiar to the subcategory. Details of the analysis are discussed in Appendix B. The final results are the five equations described in Section II.A.2.a.

Total fuel consumption by the five commercial subcategories is then computed by summing the five fuel consumption estimates:

$$T_c = \sum_{j=1}^{5} T_j$$

where T_c = total county fuel consumption by the five commercial subcategories (therms)

T_j = county total fuel consumption for commercial subcategory j (j = 1 for hospitals, j = 2 for hotels, j = 3 for universities, j = 4 for schools, and j = 5 for commercial laundries)

3. Distributing Total Fuel Consumption by the Five Commercial Subcategories to Each Fuel Type

The total consumption by the five subcategories must then be distributed among the four fuel types. Two methods of accomplishing this were identified:

- Distribution according to the state commercial fuel use pattern
- Distribution according to the residential fuel use pattern of each county

Walden elected to use the latter because it reflects variation in fuel use patterns between urban and rural counties. Relative consumption of the different fuel types is generally reflected by the proportion of dwelling units using the corresponding fuel types for space heating. Data on the number of dwelling units by heating fuel type, available from the Bureau of the Census [4], are used for this apportionment, as follows:

$$T_{i,c} = T_c * \frac{U_{i,c}}{U_c}$$

where $T_{i,c}$ = consumption of fuel type i in county c (therms)

$U_{i,c}$ = number of occupied dwelling units in county c using fuel type i for space heating

$$U_c = U_{o,c} + \sum_{i=1}^{4} (U_{i,c} : X_i > 0)$$

with X_i = statewide consumption of fuel type i by commercial area sources

The portion of total fuel consumption that is attributed to fuel oil is accounted for by including dwelling units using fuel oil for space heating in the total used in the denominator ($U_{o,c}$).

4. Determining Normalization Factors and Consumption by Commercial Sources Other Than the Five Major Subcategories

Statewide consumption of each fuel type by commercial sources other than the five major subcategories is computed by subtracting the calcualted state five-subcategory consumption from the actual state consumption. If, however, the calculated five-subcategory consumption exceeds the actual state consumption, the five-subcategory estimates must be normalized against the actual state total. State fuel consumption by "other" commercial sources and normalization factors are determined as follows:

If $X_i > F_i$, then $FO_i = X_i$ and $n_i = 1$

If $X_i \leq F_i$, then $FO_i = 0$ and $n_i = \frac{X_i}{F_i}$

where X_i = actual state commercial area source consumption of fuel type i

F_i = calculated state five commercial subcategory consumption of fuel type i

FO_i = state consumption of fuel type i by "other" commercial sources

n_i = normalization factor for consumption of fuel type i by five commercial subcategories

5. Calculating County Area Source Consumption by Commercial-Institutional Sources

Statewide fuel consumption by "other" commercial sources is apportioned to the counties on the basis of employment in that category. Total county consumption of each fuel type by commercial sources is obtained by adding the county consumption by the five commercial subcategories to the consumption by the "other" commercial sources:

$$F_{i,c} = n_i \, f_i \, T_{i,c} + FO_i \left(\frac{E_c}{E_s} \right)$$

where $F_{i,c}$ = county commercial area source consumption of fuel type i

f_i = factor to convert fuel type i from therms to appropriate NEDS units

E_c = county area source employment in "other" commercial category

E_s = state area source employment in "other" commercial category

C. INDUSTRIAL

A procedure was developed for allocating state industrial area source consumption of natural gas, LPG, and bituminous coal. Anthracite coal consumed by industry is almost entirely used by large point sources, implying that industrial area source consumption of anthracite coal is negligible. This approach has been adopted here and is consistent with the EPA Guide [35].

The procedure for determining countywide fuel consumption by industrial area sources is comprised of four basic steps:

- Developing statewide fuel intensity ratios for each fuel type by each of twenty 2-digit SIC categories
- Estimating state consumption, reported by SIC category, to individual counties on the basis of the fuel intensity ratios and county area source employment in each SIC category
- Deriving actual state industrial area source fuel consumption

- Normalizing estimated county industrial area source fuel use against actual state consumption

1. Developing State Fuel Intensity Ratios

The fuel intensity ratio (FIR) is a measure of the intensity of fuel use per employee. FIRs are stratified according to twenty 2-digit SIC categories in order to reflect the large variation in fuel use intensity among various types of industry. The industries used correspond to SIC categories 20-39. One set of FIRs is computed for bituminous coal, and one set is computed for a combination of natural gas and the gas equivalent of LPG.

In order to account for geographic variation in fuel use intensity, FIRs are calculated separately for each state. A set of national-level FIRs is also calculated. The national FIRs are substituted in cases for which the requisite state-level fuel and employment data are unavailable.

Table 3-4 illustrates the dependence of the value of FIRs on industry type, fuel type, and geographic region.

Fuel consumption data, which are used to estimate FIRs, are available primarily from two sources, the Annual Survey of Manufactures [36] and the Census of Manufactures [14]. The Annual Survey reports energy consumption as measured by dollars spent by SIC group for the country as a whole. Table 3-5, extracted from the Census of Manufactures, shows quantity of fuel purchased by SIC group and by type of fuel for each state. Although these Census data are available only at 5-year intervals, the stratification of the fuel data is directly applicable to the proposed methodology. Consequently, the census is the preferred source for fuel use data for FIR determination. State-level industrial employment by SIC class is obtained from the County Business Patterns [13]. National employment is obtained by summing over the states.

The FIRs are calculated by taking the ratio of fuel consumption by a particular industry to the employment in that industry:

TABLE 3-4

FUEL INTENSITY RATIOS

SIC	Natural Gas (Ft.^{3} x 10^6/Employee)			Coal (Tons/Employee)		
Category	California	Pennsylvania	National	California	Pennsylvania	National
20	0.503	0.130	0.309	2.89*	2.34	2.89
21	0.061*	0.061*	0.061	2.64*	2.64*	2.64
22	0.188	0.054	0.111	1.71*	0.698	1.71
23	0.004	0.004	0.011	0.111*	0.050	0.111
24	0.116	0.132	0.132	0.092*	0.342*	0.342
25	0.029	0.040	0.044	0.528*	0.966	0.528
26	0.677	0.431	0.751	0.192	0.963	14.9
27	0.031	0.022	0.036	0.017*	0.012	0.017
28	1.07	0.272	1.67	21.5*	25.2	21.5
29	8.16	13.8	9.67	2.62*	15.8	2.62
30	0.167	0.114	0.148	2.40*	1.74	2.40
31	0.029*	0.035	0.029	0.415*	1.13	0.415
32	1.81	0.934	1.24	0.016	39.1	17.1
33	0.677	1.04	0.925	0.066	9.67	7.94
34	0.132	0.131	0.123	0.509*	0.388	0.509
35	0.041	0.075	0.086	0.008	0.399	0.697
36	0.040	0.063	0.065	0.413*	0.994	0.413
37	0.066	0.076	0.085	1.57*	2.06	1.57
38	0.031	0.037	0.043	1.88*	7.91	1.88
39 (includes 19)	0.032	0.097	0.063	0.210*	0.299	0.210

* National FIR used because shipments for state not reported separately.

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TABLE 3-5

TABLE 4. Quantity and Cost of Purchased Fuels Used for Heat and Power by State and Industry Group: 1971[1]

Code	State and industry group	Bituminous coal, lignite and anthracite: Quantity (1,000 short tons) Col. I	Bituminous coal, lignite and anthracite: Cost (million dollars) Col. J	Coke and breeze: Quantity (1,000 short tons) Col. K	Coke and breeze: Cost (million dollars) Col. L	Natural gas: Quantity (billion cu. ft.) Col. M	Natural gas: Cost (million dollars) Col. N	Other fuels (million dollars) Col. O	Fuels not specified by kind (million dollars) Col. P	Standard error of estimate (percent)[2] for column— J	Standard error of estimate (percent)[2] for column— N
	West Virginia, total	4,709.1	41.4	(S)	0.5	66.6	35.0	3.1	0.2	1	1
28	Chemicals and allied products	3,310.6	29.7	-	-	19.5	10.0	1.1	-.3	1	1
29	Petroleum and coal products	22.7	.2	-	-	1.0	.5	-	(Z)	1	12
32	Stone, clay, and glass products	215.9	2.7	-	-	25.0	13.2	.3	.6	1	3
33	Primary metal industries	1,045.6	7.5	(S)	.5	15.8	8.3	.4	-.9	1	1
34	Fabricated metal products	1.3	(Z)	-	-	1.5	.9	(Z)	.1	1	9
35	Machinery, except electrical	-	-	(S)	(Z)	.4	.3	(Z)	.1	(X)	3
36	Electrical equipment and supplies	.2	(Z)	-	-	.9	.4	(Z)	.1	1	1
	North Carolina, total	1,767.7	24.8	(S)	2.3	66.4	35.5	6.7	21.0	1	2
20	Food and kindred products	4.3	.1	(S)	(Z)	3.8	2.2	.7	3.3	1	4
21	Tobacco manufactures	132.6	2.2	-	-	.7	.4	.1	.4	1	1
22	Textile mill products	617.4	8.4	-	-	22.2	13.1	1.5	5.5	2	3
23	Apparel, other textile products	19.6	.3	-	-	.5	.3	(Z)	.6	4	1
24	Lumber and wood products	1.7	(Z)	-	-	1.1	.6	2.3	4.1	41	69
25	Furniture and fixtures	65.8	1.1	(S)	(Z)	.6	.4	.2	1.2	5	10
26	Paper and allied products	608.4	9.2	(S)	.9	2.4	1.1	.2	-	1	12
28	Chemicals and allied products	217.0	3.3	-	-	16.8	7.9	.1	1.2	1	1
30	Rubber and plastics products, n.e.c.	-	-	-	-	1.1	.6	.1	.4	(X)	3
32	Stone, clay, and glass products	2.7	(Z)	(S)	.9	8.4	4.0	.8	2.2	42	15
33	Primary metal industries	-	-	(S)	.3	1.9	1.2	.2	(Z)	(X)	4
34	Fabricated metal products	-	-	-	-	1.2	.8	(Z)	.7	(X)	5
35	Machinery, except electrical	-	-	(S)	.1	1.6	.9	.2	.3	(X)	12
36	Electrical equipment and supplies	(Z)	-	-	-	2.1	1.2	.1	.4	(X)	1
38	Instruments and related products	1.7	(Z)	-	-	.7	.4	(Z)	(Z)	1	1
39	Miscellaneous manufacturing industries	.5	(Z)	-	-	.4	.2	-	(Z)	67	6
	South Carolina, total	1,609.4	21.1	(S)	.1	63.7	32.1	4.2	8.9	1	2
22	Textile mill products	383.5	5.0	(S)	(Z)	21.2	11.1	1.6	2.5	1	1
23	Apparel, other textile products	87.7	.9	-	-	1.2	.7	(Z)	.6	1	2
24	Lumber and wood products	.1	(Z)	-	-	.6	.3	.8	2.4	1	27
25	Furniture and fixtures	-	-	-	-	.1	(Z)	(Z)	.1	(X)	42
26	Paper and allied products	76.8	1.1	-	-	6.8	3.1	.5	.3	1	1
28	Chemicals and allied products	1,046.8	14.0	-	-	12.5	5.8	.4	.2	1	6
30	Rubber and plastics products, n.e.c.	-	-	-	-	1.6	.8	.1	.1	(X)	1
32	Stone, clay, and glass products	-	-	-	-	12.5	6.2	.2	1.5	(X)	3
33	Primary metal industries	-	-	-	-	.9	.6	(Z)	(Z)	(X)	1
35	Machinery, except electrical	-	-	(S)	.1	1.2	.7	.1	.4	(X)	7
36	Electrical equipment and supplies	-	-	-	-	.6	.4	(Z)	.2	(X)	1
37	Transportation equipment	-	-	-	-	.1	(Z)	(Z)	.1	(X)	15
38	Instruments and related products	-	-	-	-	.4	.2	(Z)	(Z)	(X)	1
39	Miscellaneous manufacturing industries	-	-	-	-	.3	.2	(Z)	.1	(X)	3
	Georgia, total	535.6	6.5	(S)	.6	104.0	51.3	10.3	15.3	1	1
20	Food and kindred products	.3	(Z)	-	-	10.1	5.0	1.0	1.1	1	5
22	Textile mill products	141.8	1.8	(S)	(Z)	21.6	10.6	.5	2.5	1	2
23	Apparel, other textile products	2.0	(Z)	-	-	1.4	.6	(Z)	.7	1	3
25	Furniture and fixtures	1.3	(Z)	-	-	.3	.2	(Z)	.2	1	10
26	Paper and allied products	273.2	3.0	-	-	18.7	8.7	4.7	.4	1	1
27	Printing and publishing	-	-	-	-	.7	.3	.1	.2	(X)	20
28	Chemicals and allied products	104.4	.9	(S)	(Z)	14.0	7.3	.4	.9	1	5
30	Rubber and plastics products, n.e.c.	-	-	-	-	1.8	.8	(Z)	.2	(X)	3
31	Leather and leather products	-	-	-	-	(Z)	(Z)	-	(Z)	(X)	1
32	Stone, clay, and glass products	62.9	.8	(S)	(Z)	19.7	9.3	.8	.4	1	7
33	Primary metal industries	-	-	(S)	.5	4.0	2.0	.2	.4	(X)	1
34	Fabricated metal products	-	-	(S)	(Z)	1.3	.6	.2	.4	(X)	6
35	Machinery, except electrical	.1	(Z)	(S)	.1	.9	.5	.1	.2	1	11
36	Electrical equipment and supplies	-	-	-	-	1.0	.6	(Z)	.3	(X)	1
37	Transportation equipment	-	-	-	-	3.8	2.2	.7	.2	(X)	1
	Florida, total	37.5	.3	(S)	.1	73.7	31.9	7.6	8.5	1	1
20	Food and kindred products	-	-	-	-	10.1	5.0	.8	2.8	(X)	1
26	Paper and allied products	-	-	-	-	13.4	5.9	.6	.2	(X)	1
28	Chemicals and allied products	37.5	.3	-	-	36.1	13.0	1.4	.3	1	1
29	Petroleum and coal products	-	-	-	-	.3	.2	(Z)	.5	(X)	1
30	Rubber and plastics products, n.e.c.	-	-	-	-	.1	(Z)	.1	.1	(X)	37
32	Stone, clay, and glass products	-	-	-	-	9.6	5.2	1.5	1.7	(X)	1
33	Primary metal industries	-	-	(S)	.1	1.3	.8	.2	.5	(X)	1
34	Fabricated metal products	-	-	-	-	1.2	.8	.1	.6	(X)	12
38	Instruments and related products	-	-	-	-	(Z)	(Z)	(Z)	.1	(X)	1
39	Miscellaneous manufacturing industries	-	-	-	-	.1	.1	-	.2	(X)	40

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[1] Data from Annual Survey of Manufactures [36].

$$FIR_{ij} = F_{ij}/E_j$$

where FIR_{ij} = fuel intensity ratio for fuel type i and SIC category j

F_{ij} = consumption of fuel type i by SIC category [14]

E_j = employment in SIC category j [14]

2. Estimating County Consumption

The basic algorithm for determining countywide industrial area source fuel use is represented by the sum of the products of each state FIR and the corresponding county area source employment:

$$F_{i,c} = \sum_{j=20}^{39} (E_{j,c} - P_{j.c})\, FIR_{ij}$$

where $F_{i,c}$ = estimated county industrial area source consumption of fuel type i

$E_{j,c}$ = county employment for SIC category j (CBP)

$P_{j,c}$ = county point source employment for SIC category j (NEDS)

Consistent with the discussion in the previous section, the state FIR will be replaced by the national analog if state-level data are not disclosed in the census.

3. Derivation of Actual State Industrial Area Source Fuel Consumption

a. Natural Gas

Statewide consumption of natural gas (including LPG) by industrial area sources is derived by deducting point source consumption of natural gas and LPG from published data on total industrial sales of natural gas and LPG, as follows:

$$X_1 = (G - G_p) + f(L - L_p)$$

where X_1 = state total gas equivalent consumption by industrial area sources

G = total state industrial natural gas sales

G_p = statewide natural gas consumption by industrial point sources

L = total state industrial LPG sales

L_p = statewide LPG consumption by industrial point sources

f = factor to convert LPG to natural gas equivalent

The source of data on sales of natural gas by state and user category is the Bureau of Mines MIS Natural Gas Production and Consumption [6]. LPG sales data are compiled by the Bureau of Mines and reported annually in the MIS Sales of Liquified Petroleum Gas and Ethane [8]. The Bureau of Mines data are compiled from surveys of producers, pipelines, and distribution. Detailed analysis of the merits of these data sources for estimating state natural gas consumption is given in Appendix C.

b. Bituminous Coal

Statewide consumption of bituminous coal by industrial users is not currently reported. Instead, this is estimated from data on total shipments to the states and the national distribution by user category, using consumption and shipments reported by the United States Bureau of Mines [10]. The derivation of state-by-state consumption of bituminous coal is discussed in detail in Appendix C and is summarized by the equation below:

$$X_2 = \frac{B_N}{\Sigma B_s} (B_s - B_p)$$

where X_2 = statewide consumption of bituminous coal by industrial area sources

B_N = published national total consumption of bituminous coal by industrial sources

B_s = published state shipments of bituminous coal for industrial consumption

B_p = statewide consumption of bituminous coal by industrial point sources

4. Normalization

Estimates of county industrial area source consumption of natural gas and bituminous coal are normalized against actual state industrial area source consumption as follows:

$$F'_{i,c} = F_{i,c} \left(\frac{X_i}{F_i}\right)$$

where $F'_{i,c}$ = normalized county industrial area source consumption of fuel type i (i = 1 for natural gas, i = 2 for bituminous coal)

$F_{i,c}$ = estimated industrial area source consumption of fuel type i in county c

F_i = $\sum_{c} F_{i,c}$

X_i = actual state industrial area source consumption of fuel type i

D. OFF-HIGHWAY CONSUMPTION OF GASOLINE AND DIESEL FUEL

The methodologies developed by Southwest Research Institute [15] for estimating emissions from off-highway sources were examined for their applicability to estimating off-highway fuel consumption on a county basis. The off-highway category is comprised of six components, viz., farm equipment, construction equipment, industrial equipment, motorcycles, lawn and garden equipment, and snowmobiles. Insofar as the present effort is limited to adapting the Southwest Research Institute (SWRI) methodologies for direction inclusion in this NEDS area source upgrade, the revisions of the off-highway methodology are primarily dictated by input data requirements.

In general, the SWRI methodologies for each of the six off-highway subcategories involve either apportionment of national fuel consumption total to the counties on the basis of various demographic or economic items or by direct calculation of county or state totals by applying fuel consumption rates to average usage figures and equipment populations. Total off-highway consumption of each fuel type is the total consumption of the fuel by the six subcategories. Diesel fuel consumption is assumed to be zero for motorcycles, lawn and garden equipment, and snowthrowers.

The national gasoline and diesel fuel consumption totals for construction equipment, industrial equipment, lawn and garden (other than snowthrowers) equipment, snowthrowers, and snowmobiles are given in Table 3-6. These consumption estimates were derived from data compiled by SWRI [15] and NADB [18].

The final off-highway methodology is presented in detail in Section II.A.4 of this report. The modifications to the original SWRI methodologies that were found necessary are discussed below.

1. Farm Equipment

The original SWRI methodology estimated consumption for eight farm equipment categories. Three of these--garden tractors, general-purpose small utility engines, and lawn and garden small engines--have been grouped into the lawn and garden equipment off-highway subcategory.

State consumption by the other five equipment categories is calculated from equipment populations using formula (i) in Section II.A.4.a. Because equipment population data for large utility engines are not published, equation (ii) in the same section, also developed by SWRI, is used to estimate the state equipment population for the category. Population for the other four equipment categories is available from the Census of Agriculture [16].

Total state consumption by the five farm equipment categories is apportioned to the county level on the basis of tractor population, as given by equation (iii) in Section II.A.4.a. Farm equipment data used for the 1973 update are listed in Table 3-7.

2. Construction Equipment

The county consumption of gasoline and diesel fuel by construction equipment is determined by computing the national total fuel consumption

TABLE 3-6

NATIONAL FUEL ESTIMATES FOR 1973, GALLONS

	Gasoline	Diesel
Construction Equipment	423×10^6	$7,833 \times 10^6$
Industrial Equipment	$944,162 \times 10^3$	$1,064,705 \times 10^3$
Lawn and Garden	$583,467 \times 10^3$	---
Snowthrowers	$17,504 \times 10^3$	---
Snowmobiles	$82,593 \times 10^3$	---

Source: National Air Data Branch, U.S. Environmental Protection Agency [18].

TABLE 3-7

USAGE RATES, CONSUMPTION RATES, AND POPULATION DISTRIBUTION FOR HEAVY-DUTY AGRICULTURAL ENGINES USED FOR 1973 UPDATE

	Annual Usage (Hours/Year)	Fuel Consumption Rate (gallons/hour)		Population Density (percentage)	
		Gasoline	Diesel	Gasoline	Diesel
Combines	71	2.34	1.5	57	43
Bailers	24	2.34	1.5	100	0
Harvesters	120	2.34	1.5	0	100
General Purpose	50	3.51	1.94	50	50
Tractors	*	2.28	2.98	65	30**

* 490 hours/year diesel, 291 hours/year gasoline

** About 5% is LPG, which is not included here

Source: National Air Data Branch, U.S. Environmental Protection Agency [18] by construction equipment and apportioning this to the state level according to total non-building employment.

The state's share of the national total is allocated to individual counties on the basis of population. The formula for this method is given in Section II.A.4.b.

Estimates of national consumption were provided by the National Air Data Branch [13] using emission and unit consumption data compiled in the SWRI study [15].

3. Industrial Equipment

The SWRI methodology for apportioning national industrial equipment fuel consumption is based on value added, or the combined sales of mining, wholesale trade, and manufacturing industries. Due to the unavailability of these data on a county basis, the Walden method is to replace this apportioning factor with combined employment for the same categories. This change will affect the county allocation according to differences in productivity of labor between manufacturing, mining, and wholesale trade. Labor productivity in these industries is shown in Table 3-8. The effect of this change is to weight the manufacturing category more heavily than mining and wholesale trade and to weight certain industries within the manufacturing category more heavily than others (e.g., textiles, lumber, and leather products are weighted more heavily than tobacco, petroleum, and chemicals).

The formula for this apportionment is described in Section II.A.4.c. Total employment in manufacturing, mining, and wholesale trade is the sum of the figures reported in the Bureau of Census, County Business Patterns [13] for division D, division B, and major group 50, respectively.

4. Motorcycles

The SWRI approach for estimating county-level gasoline consumption by motorcycles is based on population distribution, as follows:

TABLE 3-8

1967 NATIONAL LABOR PRODUCTIVITY

	Value Added or Sales & Receipts ($\times 10^6$)	Employment ($\times 10^3$)	Value Added or Sales per Employee ($\times 10^3$)
MINING	25848.7	567.3	45.5
WHOLESALE TRADE	459475.9	3518.9	130.6
MANUFACTURING	261983.8	19323.2	13.6
SIC 19	5584.8	400.4	19.9
SIC 20	26620.9	1649.6	16.1
SIC 21	2032.0	75.1	27.1
SIC 22	8153.2	929.0	8.8
SIC 23	10064.4	1356.7	7.4
SIC 24	4973.4	554.0	8.9
SIC 25	4169.5	425.3	9.8
SIC 26	9756.3	638.9	15.3
SIC 27	14355.1	1031.0	13.9
SIC 28	23550.1	841.4	27.9
SIC 29	5425.8	141.6	38.3
SIC 30	6799.5	516.7	13.2
SIC 31	2626.5	328.7	7.9
SIC 32	8333.4	589.9	14.1
SIC 33	19978.2	1281.0	15.6
SIC 34	18042.6	1341.8	13.4
SIC 35	27836.4	1864.5	14.9
SIC 36	24487.3	1874.9	13.1
SIC 37	28173.9	1834.1	15.4
SIC 38	6418.4	394.3	16.3
SIC 39	4599.4	423.1	10.9

Data were obtained from the following sources:

1967 Census of Manufactures, Volume III, Area Statistics

1967 Census of Manufactures, Volume IV, Wholesale Trade, Area Statistics

1967 Census of Mineral Industries, Series MIC67(2).

$$F_m = \left(\frac{P_c}{P_s}\right) M * FR * U$$

where F_m = county consumption of gasoline by motorcycles (gallons)
P_c = county population [19]
P_s = state population [19]
M = state motorcycle registrations [20]
U = average annual usage per unit (miles/year) [15]
FR = fuel consumption rate (miles/gallon) weighted by engine size and corresponding distance traveled [15]

A refinement of this method, separating off-road and combination motorcycles and weighting the distribution of these two types according to regional variations, is used for the allocation. The formula used is described in Section II.A.4.d.

State motorcycle registration data are available from the Federal Highway Administration's Highway Statistics [20]. The national usage rate and usage factors for the two types of motorcycles are extracted from the Henrix, Tucker, and Walker study [21]. The national fuel consumption rate is estimated to be 0.0235 gallons/mile [15]. The consumption rate for off-road and combination motorcycles is assumed to be the same.

5. Lawn and Garden Equipment

The original SWRI methodology for allocation of natural lawn and garden fuel consumption to individual counties is based on a combination of the number of single-unit structures, the number of freeze-free days (i.e., the number of days with a minimum temperature > 32°F), the fraction of national snow zone population that is in the county (the snow zone is all areas with an annual snowfall > 30 inches), snowthrower fuel consumption rate, average snow removal rate, and county snowfall [15]. The final equation for the lawn and garden methodology is given in Section II. A.4.e.

Data on population and the number of dwelling units in single-unit structures are reported in the Bureau of Census Census of Housing [4].

County snowfall and the number of freeze-free days are compiled from the Environmental Data Service Climatological Data [3]. Climatological data from this source are obtained for a selected, representative weather station in the county.

6. Snowmobiles

National gasoline consumption by snowmobiles is apportioned to a county on the basis of the county's share of the snowmobile population. While state snowmobile populations are generally available from registration data [15], county breakdown is not. To estimate county-level snowmobile population, a set of regression formulations developed by SWRI [15] is used to relate the percent of state snowmobiles used in the county to population and snowfall. A distinction is made to reflect the impact of population density on snowmobile usage. Equations (i) and (ii) in Section II.A.4.f are the formulae used to estimate the fraction of state snowmobile population that is in each county. Equations (iii) and (iv) in Section II.A.4.f are then used to compute county snowmobile population and to apportion the national snowmobile gasoline consumption to the counties. Centroid counties, used to determine snowfall at the center of the state, are listed for each state in Table 3-9.

E. GASOLINE CONSUMPTION BY MARINE VESSELS

The SWRI methodology for apportioning state gasoline for marine uses is based on inland water area, using the formula

$$G_v = N_v * \left(\frac{W_c}{W_s}\right) * 10 * M_c * FR_v$$

where G_v = county consumption of gasoline by marine vessels

N_v = state boat registrations

W_c = county inland water area

$W_s = \sum_c W_c$

M_c = number of warm months (which promote boating activities)

FR_v = average fuel consumption rate (gallons/hour)

TABLE 3-9

CENTROID COUNTIES FOR EACH SAROAD STATE

SAROAD State Number	State Name	Centroid County SAROAD Number	Centroid County Name
1	Alabama	660	Chilton
2	Alaska	620	Yukon-Koyukuk
3	Arizona	940	Yavapai
4	Arkansas	2220	Pulaski
5	California	2820	Fresno
6	Colorado	1740	Park
7	Connecticut	565	Middlesex
8	Delaware	60	Kent
9	District of Columbia	20	District of Columbia
10	Florida	580	Citrus
11	Georgia	5160	Twiggs
12	Hawaii	140	Honolulu
13	Idaho	540	Custer
14	Illinois	4400	Logan
15	Indiana	2640	Marion
16	Iowa	3480	Story
17	Kansas	3100	Rice
18	Kentucky	340	Boyd
19	Louisiana	2260	Coupee
20	Maine	595	Knox
21	Maryland	80	Anne Arundel
22	Massachusetts	369	Central Massachusetts
23	Michigan	1000	Clare
24	Minnesota	2360	Morrison
25	Mississippi	1520	Leake
26	Missouri	3040	Miller
27	Montana	460	Fergus
28	Nebraska	640	Custer
29	Nevada	300	Lander
30	New Hampshire	440	Merrimack
31	New Jersey	2980	Mercer
32	New Mexico	1200	Torrance
33	New York	5260	Otsego
34	North Carolina	1840	Harnett
35	North Dakota	1060	Sheridan
36	Ohio	3440	Licking
37	Oklahoma	2180	Oklahoma
38	Oregon	420	Crook
39	Pennsylvania	1520	Centre
40	Puerto Rico	—	—

TABLE 3-9

CENTROID COUNTIES FOR EACH SAROAD STATE

SAROAD State Number	State Name	Centroid County SAROAD Number	Centroid County Name
41	Rhode Island	140	Kent
42	South Carolina	460	Calhoun
43	South Dakota	1560	Stanley
44	Tennessee	2960	Rutherford
45	Texas	1000	Coleman
46	Utah	980	Sanpete
47	Vermont	500	Washington
48	Virginia	540	Buckingham
49	Washington	1940	Skagit
50	West Virginia	160	Braxton
51	Wisconsin	4060	Wood
52	Wyoming	460	Natrona

This methodology was modified by Walden to allow for accounting separately for inboard and outboard vessels and to include county coastline in the apportioning algorithm. The formula for this final method is given in Section II.A.5.

Inland water area is reported in the Bureau of Census Area Measurements Reports [22]. State registrations for inboards are as reported in the Marine Market [23], and outboard data are available from Boating 1972 [24]. Fuel consumption rates for inboards and outboards are assumed to be 3 and 1.5 gallons/hour, respectively [15]. Normal temperatures (based on 1931-1960 data) are generally unavailable for many of the stations that are used to represent county climatology. Consequently, the proposed monthly average temperatures are obtained for representative counties for each station from NOAA [3]. Limited availability of data precludes any reliable estimates of the factor to convert coastline to an area equivalent; for the purposes of the 1973 run, it was assumed to equal 1.

F. RAILROAD CONSUMPTION OF DIESEL FUEL

A number of alternative apportionment schemes were investigated, as described in Appendix D. As a result of this analysis, the selected method is to apportion state consumption of diesel fuel by railroads to the county level on the basis of population distribution. The formula for this methodology is described in Section II.A.6.

Data on the use of diesel fuel by railroads for each state are obtained from the Bureau of Mines Mineral Industry Survey [25].

G. RETAIL SALES OF GASOLINE

Retail sales of gasoline include all gasoline sold for highway use and for use by construction equipment, industrial equipment, farm equipment, and aviation off-highway categories. For states which compile and can make available gasoline sales data on a county basis, the countywide retail [illegible] data are used directly. State tax departments are the source of such data. Only Arizona, Georgia, Louisiana, Minnesota, and New Mexico, representing approximately 15% of all counties, currently provide county breakdowns of retail gasoline sales. For those counties where retail sales of gasoline are not compiled, sales to the five retail user categories in the county are estimated separately and summed to give total county sales.

Consumption by construction equipment, industrial equipment, and farm equipment is computed using the off-highway methodologies for these categories described in Sections II.A.4.a, b, and c.

Published state aviation gasoline sales are apportioned according to total landing and take-off (LTO) cycles of aircraft in the county. LTO cycles are apportioned to counties according to the methodology described in Section II.A.10.

State retail sales of gasoline for highway use are derived from total state gasoline sales by subtracting reported state totals of the four off-highway category consumption categories. These data are reported in the Federal Highway Administration (FHWA) publication Highway Statistics [20]. Total retail sales of gasoline for highway consumption are calculated by subtracting the highway use of special fuels (Table MF-25*) from the total highway motor fuel use (Table MF-21*). Use of gasoline by the four off-highway user subcategories is reported separately in Table MF-24.* This state component will include sales of gasoline for marine use, since marine service stations are generally grouped with highway service stations. Similarly, other miscellaneous uses of gasoline are included in this highway component. The state highway gasoline sales are apportioned to the county according to gross receipts of service stations, available from the Department of Commerce Census of Business [26].

The formula for allocating countywide total retail sales of gasoline is given in Section II.A.7.

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* Table MF-xx refers to table numbers in Reference 20.

H. ORGANIC SOLVENTS

1. Identification of Major Solvent Groups and Data Sources

The identification and selection of major organic solvent groups for the purpose of estimating national consumption and subsequent countywide allocation are arrived at from the results of a recent systems study on hydrocarbon pollutants [37]. Table 3-10 shows a compilation of primary industrial solvents that were considered. Of this list of candidates, the first sixteen solvent types will be considered individually, while all remaining solvent types will be grouped together as "All Other Solvents." The category "Special Naphthas," which comprises about two-thirds of total organic solvent use in the country, includes the aliphatic naphthas such as V.M. and P. naphthas, stoddard solvents, rubber solvents, and mineral spirits [38].

Total U.S. production of solvents by type is extracted from a publication of the U.S. Tariff Commission entitled, Synthetic Organic Chemicals, U.S. Production and Sales [28]. National production of special naphthas is taken from the Mineral Yearbook [27]. Data pertaining to usage patterns for the sixteen most widely used organic solvents are obtained from two principal sources, viz.,

- The Chemical Marketing Reports publish a weekly "Chemical Profile" [39] for selected chemicals. These data can be used to estimate the percentage of the solvent that is used by various industry groups.
- SRI's Chemical Economic Handbook [38], which publishes similar profiles on each chemical, but in greater detail. For perchloroethylene, for example, the data that are available include (i) producing companies; (ii) historical production figures; (iii) consumption by markets, including a description of how and in which processes the chemical is used; (iv) historical cost figures; (v) U.S. imports; (vi) foreign producing companies; and (vii) list of references.

Determination of national usage of each major organic solvent group from these data is discussed in detail in Appendix E and is summarized in Table 3-11.

TABLE 3-10

INDUSTRIAL SOLVENTS

Solvent
Special Naphthas
Perchloroethylene
Ethanol
Trichloroethylene
Toluene
Acetone
Xylene
Fluorocarbons
Methyl Ethyl Ketone
1,1,1-Trichloroethane
Methylene Chloride
Methanol
Ethylene Dichloride
Ethyl Acetate
Cyclohexane
Methyl Isobutyl Ketone
Hexanes
Benzene
n-Butanol
Nitrobenzene
Turpentine
Isopropyl Acetate
Ethyl Ether
Monochlorobenzene
Isopropanol
Diethylene Glycol
Methyl Acetate
Cresols
Phenol
Chloroethane (ethyl chloride)
Carbon Tetrachloride
Pinene
Cyclohexanol
Cyclohexanone
Ethyl Benzene
Isobutyl Alcohol
Chloromethane
n-Butylacetate
Methyl Chloride

Source: *Hydrocarbon Pollutant Systems Study*, Volume 1, Stationary Sources Effect and Control, MSA Research Corporation, Evans City, Pennsylvania, October 1972.

TABLE 3-11

1971 NATIONAL USE OF ORGANIC SOLVENTS

	Total Demand 1971 (lbsx10^6)	Surface Coatings	Degreasing	Dry Cleaning	Printing & Publishing	Rubber & Plastics	Other Miscellaneous Solvent Use	Solvent Use As % of Total Consumption
Special Naphthas VM&P Solvent Stoddard Solvent Rubber Solvent Mineral Spirits	8,711	26%		6%	8%		60%	100%
Penchloroethylene	748		15%	58%			10%	83%
Ethanol	2,023	4%					35%	39%
Trichloroethylene	539		87%				3%	90%
Toluene	3,422	5%			5%			10%
Acetone	1,660	9%					16%	25%
Xylene	3,617	6%					7%	13%
Fluorocarbons	825					10%	55%	65%
M.E.K.	491	65%					7%	72%
1,1,1-Trichloroethane	375		67%			9%	11%	87%
Methylene Chloride	380	31%	11%			11%	>37%	>90%
Methanol	749						9%	9%
Ethylene Dichloride	7,558	0.3%				2%	2.7%	5%
Ethyl Acetate	159	70%		9%	8%	10%		97%
Cyclohexane	1,747	2%				2%		4%
M.I.B.K.	190	65%					25%	90%
All Other Solvents	11,456						5.16%	5.16%

2. County Apportionment

a. Distributive Factors for Major User Categories

National consumption of organic solvents, distributed by major user categories, is apportioned to the individual counties on the basis of applicable SIC employment categories. For example, in degreasing processes use category, total solvent use is allocated to each county in proportion to the county industrial employment for SIC groups 34-39. It was estimated that 95% of all degreasing operations occur in these industries [40]. For dry cleaning applications, the countywide allocation will be made on the basis of total employment in SIC groups 7215, 7216, and 7218. In computing the total employment, the employment figure for 7216 will be inflated by a factor of two, since this SIC group represents establishments engaged in dry cleaning only, while 7215 and 7218 are for both dry cleaning and wet laundering [41]. In the category "Other Miscellaneous Solvent Use," the distributive factor is made up on one-half by county population and one-half by total industrial employment. The distributive factors for county apportionment are summarized in Table 3-12.

b. Secondary Distributions for Surface Coating and Applications

For the surface coating industry, the total solvent use is further subdivided according to the stratification of coating application shown in Figure 3-3. The reported production data by end use (see Figure 3-3) are multiplied by solvent content factors to obtain solvent production estimates for surface coating uses. The Boston AQCR hydrocarbon survey [40] indicates that average solvent content for water-based trade coatings is 3.5%; for solvent-based trade coatings, it is 53%; and for industrial coatings, approximately 67%. When the solvent production estimates for surface coating uses are applied against the national consumption estimates for all types of solvent, the secondary distribution percentages and consumption of the surface coating category are obtained. The results are exhibited in Table 3-13.

TABLE 3-12

DISTRIBUTIVE FACTORS FOR ORGANIC SOLVENTS BY USER CATEGORIES

User Categories	SIC Industry	Distributive Factor
Surface Coatings		
Trade Paints-Auto Refinishing		County Population
Auto Refinishing (Trade)	7535 (Paint Shops)	
Automotive	371 (Motor Vehicles)	
Wood Furniture & Fixtures	25 (Furniture & Fixtures)	
Metal Furniture & Fixtures		
Metal Containers	34 (Fabricated Metal Products)	
Sheet Strip & Coil		
Appliances	35 & 36 (Machinery, Electrical Equipment & Supplies)	
Machinery & Equipment		
Paper	26 (Paper & Allied Products)	
Factory-Finished Wood	243, 244 (Millwork, Plywood-Related Supplies, Wooden Containers)	
Transportation (Non-Auto)	37 (Transportation Equipment) Less 371 (Motor Vehicles) & 373 (Shipbuilding Repair)	
Electric Insulation	36 (Electrical Equipment & Supplies)	
Other, Exterior, Interior	19-39 (Total Manufacturing)	
Marine	373 (Shipbuilding & Repair)	
Degreasing	34-39 (Metal Products, Machinery, Transportation Equipment, Instruments, Miscellaneous)	
Dry Cleaning	2 x 7216, Plus 7215 & 7218 (Dry Cleaning & Combination with Wet Laundering)	
Printing	264, 265, & 27 (Paper Products, Containers, Printing & Publishing)	
Rubber and Plastics	30 (Rubber & Plastics)	
Other Miscellaneous Use	1/2 by 19-39 Employment	1/2 by Population

FIGURE 3-3

SURFACE COATINGS

Estimated Production Value and Production in 1970

(Millions of Dollars/Millions of Gallons)

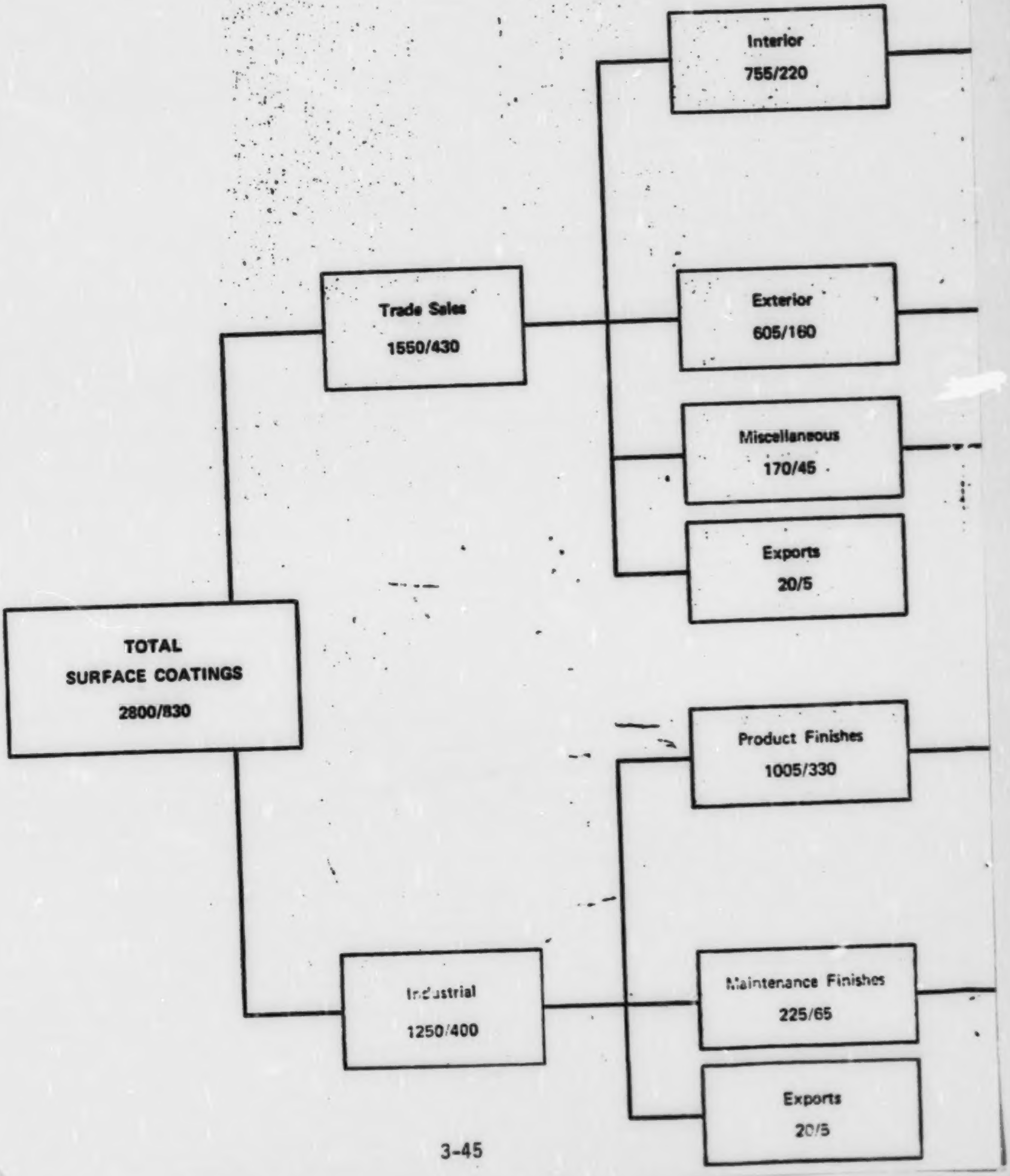

TOTAL SURFACE COATINGS
2800/830
Trade Sales
1550/430
Interior
755/220
Exterior
605/160
Miscellaneous
170/45
Exports
20/5
Industrial
1250/400
Product Finishes
1005/330
Maintenance Finishes
225/65
Exports
20/5

FIGURE 3-3 (continued)

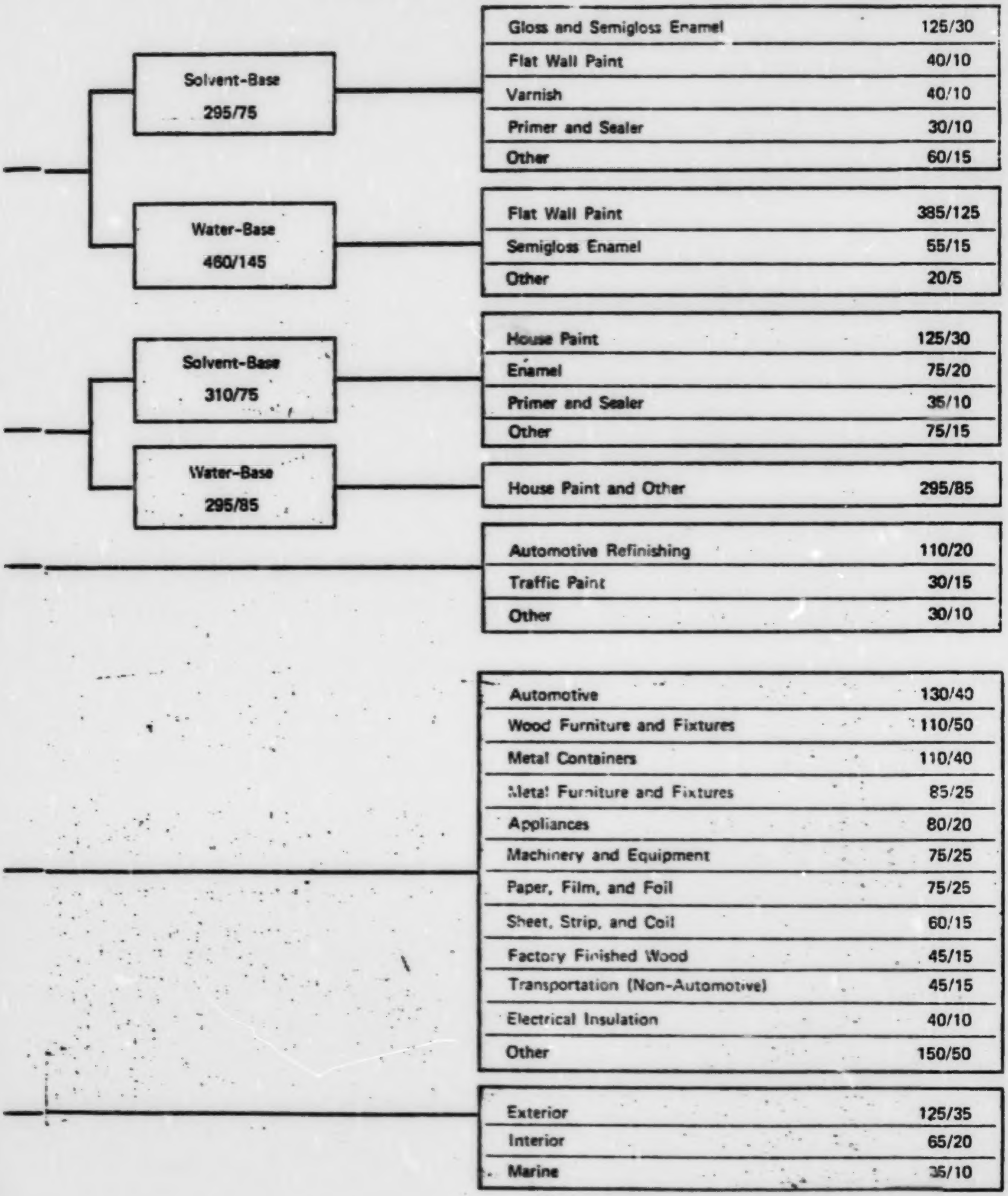

Solvent-Base
295/75
Gloss and Semigloss Enamel 125/30
Flat Wall Paint 40/10
Varnish 40/10
Primer and Sealer 30/10
Other 60/15
Water-Base
460/145
Flat Wall Paint 385/125
Semigloss Enamel 55/15
Other 20/5
Solvent-Base
310/75
House Paint 125/30
Enamel 75/20
Primer and Sealer 35/10
Other 75/15
Water-Base
295/85
House Paint and Other 295/85
Automotive Refinishing 110/20
Traffic Paint 30/15
Other 30/10
Automotive 130/40
Wood Furniture and Fixtures 110/50
Metal Containers 110/40
Metal Furniture and Fixtures 85/25
Appliances 80/20
Machinery and Equipment 75/25
Paper, Film, and Foil 75/25
Sheet, Strip, and Coil 60/15
Factory Finished Wood 45/15
Transportation (Non-Automotive) 45/15
Electrical Insulation 40/10
Other 150/50
Exterior 125/35
Interior 65/20
Marine 35/10

TABLE 3-13

DISTRIBUTION FACTORS FOR SURFACE COATING SOLVENT USE 1971

Coating Usage Type	SIC Groups	% of Surface Coatings Solvent Use
Trade Paints-Auto Refinishing	Population Distribution	26.8%
Auto Refinishing (Trade)	7535 Paint Shops	2.8%
Automotive	371 Motor Vehicles	7.1%
Wood Furniture & Fixtures Metal Furniture & Fixtures	25 Furniture & Fixtures	13.4%
Metal Containers Sheet Strip & Coil	34 Fabricated Metal Products	9.8%
Appliances Machinery & Equipment	35 & 36 Machinery, Electrical Equipment & Supplies	8.0%
Paper	26 Paper & Allied Products	4.4%
Factory-Finished Wood	243, 244 Millwork, Plywood-Related Supplies, Wooden Containers	2.7%
Transportation (Non-Automobile)	37 Transportation Equipment Less 371 Motor Vehicles & 373 Shipbuilding Repair	2.7%
Electric Insulation	36 Electrical Equipment & Supplies	1.8%
Other, Exterior, Interior	Total Manufacturing Equipment	18.7%
Marine	373 Shipbuilding & Repair	1.8%
	TOTAL	100%

The formula used in allocating organic solvent use to counties is given in Section II.A.8.

I. SULFUR AND ASH CONTENT OF COAL

In developing a methodology for determining sulfur and ash content of coal, a limited survey was conducted of state and local air pollution control agencies which may compile data on local point sources as part of their compliance enforcement activities. It was determined that, due to incompletion, state and local regulatory agencies do not represent a useful source of data on sulfur and ash in coal. The final methodology that was developed is divided into the two types of coal discussed below.

1. Bituminous and Lignite

The procedure for estimating sulfur and ash content of bituminous coal at the county level consists of three steps:

- Determine sulfur and ash content of coal associated with each production district or production district grouping (see Section II.A.9.a.(1)).
- Compute sulfur and ash content of coal shipped to each state for industrial users and retail users.
- Compute sulfur and ash content of coal used in each county according to industrial and retail bituminous coal consumption.

a. Coal Production District Sulfur and Ash Content

As explained in Section II.A.9.a.(1), weighted averages of sulfur and ash content of coal from each production district must be taken of industrial coal and coal for other uses. These data correspond to the "Other Industrial Users and Retail Dealers" and "All Other Users" categories, respectively, as reported by the Bureau of Mines and published annually [75]. Table 3-14 presents an illustration of these data for the year 1972. This approach excludes accounting for coal shipments to electric utilities and coke and gas plants. Also, as previously explained, sulfur and ash data for several production districts must be combined, due to the

TABLE 3-14

Reproduced from best available copy.

Shipments of bituminous coal and lignite by average sulfur content by consumer use in 1972

	Quantity shipped (thousand short tons)						Average sulfur content (percent)					
District	Electric Utilities	Coke and gas plants	Other industrial uses and retail dealers	All other uses	Exports (overseas and Canada)	Total 1/	Electric Utilities	Coke and gas plants	Other industrial uses and retail dealers	All other uses	Exports (overseas and Canada)	Total
1. Eastern Pennsylvania	20,354	3,290	2,506	886	1,628	28,664	2.2	0.9	1.9	2.1	1.7	2.0
2. Western Pennsylvania	5,237	14,914	3,126	2,670	724	26,671	2.1	1.5	1.7	1.7	2.3	1.7
3. Northern West Virginia	19,104	2,156	2,100	859	3,216	27,435	2.7	1.2	2.4	2.0	1.8	2.5
4. Ohio	33,625	—	5,633	1,242	—	40,508	3.5	—	3.0	2.9	—	3.4
5. Michigan	—	—	—	—	—	—	—	—	—	—	—	—
6. Panhandle	8,874	—	271	179	—	9,324	3.9	—	3.0	2.8	—	3.9
7. Southern Numbered 1	439	6,939	427	274	10,175	18,254	.8	.7	.8	1.0	.7	.7
8. Southern Numbered 2	28,765	16,950	5,810	10,286	7,095	68,906	1.1	.8	.9	.9	.8	.9
9. West Kentucky	43,883	—	2,144	1,020	—	47,047	4.6	—	3.7	3.7	—	4.0
10. Illinois	44,158	2,782	7,190	1,459	—	55,589	3.4	.8	2.8	2.9	—	3.2
11. Indiana	16,335	—	4,373	11	—	20,719	3.4	—	3.4	3.9	—	3.4
12. Iowa	702	—	—	18	—	720	3.4	—	—	4.0	—	3.4
13. Southeastern	7,982	4,107	831	193	247	13,360	1.7	1.0	2.0	1.1	1.3	1.3
14. Arkansas-Oklahoma	—	376	191	—	210	777	—	1.3	1.6	—	1.5	1.3
15. Southwestern	6,922	58	100	212	—	7,292	4.9	.5	4.1	3.8	—	4.8
16. Northern Colorado	556	—	16	2	—	574	.5	—	.3	.3	—	.5
17. Southern Colorado	1,871	1,720	239	23	192	4,045	.6	.6	.5	.7	.5	.6
18. New Mexico	10,157	—	10	1	—	10,168	.6	—	.5	.5	—	.6
19. Wyoming	9,135	34	479	28	—	9,676	.6	.7	.7	.6	—	.6
20. Utah	229	2,152	994	20	115	3,510	.7	.6	.6	.7	.8	.7
21. North-South Dakota	4,073	—	511	26	—	4,610	.9	—	1.0	1.0	—	.9
22. Montana	2,686	—	7	7	—	2,700	.9	—	1.1	.4	—	.9
23. Washington	668	—	29	—	—	697	1.5	—	.5	—	—	1.5
Total United States	265,755	35,478	36,987	19,416	23,602	401,246	2.9	1.0	2.3	1.6	1.0	2.3

1/ Total shipments by producers reporting sulfur content (67 percent of total U.S. production).

SOURCE U. S. BUREAU OF MINES

practice of grouping districts when reporting state shipments data [10]. Expressions for counting the weighted average sulfur content are given in Section II.A.9.a.(1).

Average ash content of coal for each production district, prior to combining into production district groupings, must be derived from data reported on individual mines, due to the absence of production figures for ash. Consequently,

$$A_j = \frac{1}{n} \sum_{k=1}^{n} a_k$$

where a_k = ash content of coal from k^{th} mine sampled in district j [47]

n = number of mines sampled in district j [47]

A_j = average ash content of coal from district j

b. Average Statewide Sulfur and Ash Content

At the state level, two sets each of sulfur and ash averages are computed, using coal distribution data reported by the Bureau of Mines [10]. The first set is for industrial coal consumed in the state, and the second is for coal shipped to retail dealers in the state. To obtain sulfur and ash contents that are more specific to area source users, the point source components of the sulfur and ash contents for both categories are subtracted from corresponding total content. This accounting is summarized by the expression in Section II.A.9.a.(2).

c. Countywide Sulfur and Ash Content

The average sulfur and ash contents of bituminous coal consumed in each county by retail and industrial area sources are weighted averages of the retail and industrial area sources' consumption in the county according to the equation given in Section II.A.9.a.(3).

2. Anthracite

Because there is only one anthracite producing region in the country (located in Southeastern Pennsylvania), the proposed methodology computes only a single sulfur and ash content for the anthracite from this region. The averages are computed from Bureau of Mines data [47] according to the formula:

$$\bar{S} = \frac{1}{n} \sum_{k=1}^{n} S_k$$

where $k = 1, \ldots, n$ is the mine's index, with a total of n mines in the sample

S_k = sulfur content of coal from the k^{th} mine

$\bar{S}$ = average sulfur content of anthracite produced

No attempt is made to weigh this average number according to amount of coal produced from each mine because this production information is not available.

The average ash content is computed in an analogous manner. This methodology implies a uniform sulfur and ash content for all anthracite used by area sources; however, this is not objectionable, due to the uniformity in the coal. The sulfur content of anthracite is consistently below 1%. The ash content exhibits greater variation among the coal seams, but this variability is minimized by the practice of mixing the coal from various beds prior to shipment [46].

J. LANDING AND TAKE-OFF CYCLES OF AIRCRAFT

Landing and take-off (LTO) cycles for military, civil, and commercial airports are determined for each category from total aircraft operations reported for each of these categories. An operation is defined by the FAA as either a take-off or a landing. LTO cycles, therefore, are one-half the reported operations. Aircraft operations data for each of the three categories are obtained from the following Federal Aviation Administration (FAA) publications:

- FAA Air Traffic Activity [42]. This publication gives the number of operations performed by commercial, civil, and military aircraft at airports with FAA-regulated control towers. These airports will include all the major non-military airfields in the United States. Operation totals are given both for itinerant flights, those that terminate at an airport other than the one at which they originated, and for local flights, those that originate and terminate at the same airport. Total operations for each aircraft category are, therefore, the sum of both itinerant and local operations.
- Military Air Traffic Activity Report [43]. This publication contains the number of operations performed by military and civil aircraft at military airfields.
- Census of U.S. Civil Aircraft [44]. This report gives the number of active civil aircraft for each county in the country. These data will be used to estimate aircraft activity for those counties without an FAA-regulated or a reporting utility airport.

For counties with FAA-regulated and/or military airports, the number of operations for commercial, civil, and military aircraft is set equal to the sum of the activities reported for each of these categories at airports located in the county. These activity data are extracted directly from the FAA Air Traffic Activity report [42] and the Military Air Traffic Activity report [43]. Airport locations are determined from the Aviation Directory [45], atlases, and road maps. General aviation activity from non-regulated airports in counties with regulated airports is assumed to be negligible.

For counties without FAA-regulated or military airports, the number of LTOs on an annual basis is assumed to be 365 times the number of reported active aircraft in the county. The number of active aircraft is extracted from the Census of U.S. Civil Aircraft [42].

IV. COMPUTER PROCESSING

A. OVERVIEW

In order to facilitate annual updating of the selected NEDS area source data items (indicated by the darkened fields on the coding form in Figure 4-1) for all SAROAD counties in the nation, the methodologies described in the previous sections were programmed for the UNIVAC 1110 system in FORTRAN IV code. A system of programs was also developed for preliminary processing of all data collected for input to the area source fuel allocation program (ASFAP). A master file comprised of all data required for input to the ASFAP program is generated by this preprocessing system. A schematic overview of the entire data processing system is illustrated in Figure 4-2.

In order to produce an updated file of NEDS area source data items, the master file that is input to the ASFAP program must be updated first. All data required for updating the master file is either available on magnetic tape or in publications from which it must be coded and keypunched. A set of preprocessing programs exists for each type of incoming data. Each set of programs is designed to operate independent of the others, due to the varying frequency of availability and update requirements of data from different sources. The final stage of each set of preprocessing programs is an update file ready to update the corresponding data items on the current version of the master file. The program that performs the update can do so for individual update files or for any combination of update files.

When all data that could be updated have been entered into the master file, the ASFAP program is run using the updated master file for input. The ASFAP program performs the allocation calculations and outputs the results on printed tables and a card-image file formatted according to NEDS specifications.

FIGURE 4-1
NATIONAL EMISSIONS DATA SYSTEM (NEDS)
ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR PROGRAMS

AREA SOURCE
Input Form
Date ______________

FORM APPROVED
OMB NO. 158-[illegible]

Name of Person
Completing Form ______________________________

State		1–2
County		3–6
AQCR		7–9

Year of Record		10–11
SIP EMISSION ESTIMATES (10^2 tons/yr)	Particulate	12–16
	SO_2	17–20
	NO_x	21–24
	HC	25–29
	CO	30–34
SULFUR CONTENT (%)	Anth. Coal	35–36
	Bitum. Coal	37–38
	Dist. Oil	39–40
	Resid. Oil	41–42
ASH CONTENT (%)	Anth. Coal	43–45
	Bitum. Coal	46–48
RESIDENTIAL FUEL	Anth. Coal 10^1 tons	49–53
	Bitumin. Coal 10^1 tons	54–59
	Dist. Oil 10^6 Gal.	60–64
	Resid. Oil 10^6 Gal.	65–68
	Nat. Gas 10^7 ft^3	69–73
	Wood 10^2 tons	74–77
Action		78
		79 A
cd		80 1

COMMERCIAL AND INSTITUTIONAL FUEL	Anth. 10^1 tons	10–14
	Bitumin. 10^1 tons	15–19
	Dist. Oil 10^6 Gals.	20–24
	Resid. Oil 10^6 Gals.	25–29
	Nat. Gas 10^7 Ft^3	30–33
	Wood 10^2 tons	34–35
INDUSTRIAL FUEL	Anth. Coal 10^1 tons	36–41
	Bitum. Coal 10^1 tons	42–47
	Coke 10^1 tons	48–51
	Dist. Oil 10^6 Gals.	52–56
	Resid. Oil 10^6 Gals.	57–61
	Nat. Gas 10^7 Ft^3	62–66
	Wood 10^2 tons	67–69
	Process Gas 10^7 ft^3	70–73
		74–77
Action		78
		79 A
cd		80 2

ON SITE INCINERATION	Residential 10^1 tons	10–15
	Industrial 10^2 tons	16–20
	Comm. Inst. 10^2 tons	21–24
OPEN BURNING	Residential 10^2 tons	25–30
	Industrial 10^2 tons	31–36
	Comm'l-Instit. 10^2 tons	37–41
GASOLINE FUEL	Light Vehicle 10^3 Gals.	42–48
	Heavy Vehicle 10^3 Gals.	49–54
	Off Hiway 10^3 Gals.	55–60
DIESEL FUEL	Heavy Vehicle 10^3 Gals.	61–66
	Off Hiway 10^4 Gals.	67–71
	Rail Locomotive 10^4 Gals.	72–76
Pos Con		77
Action		78
		79 A
cd		80 3

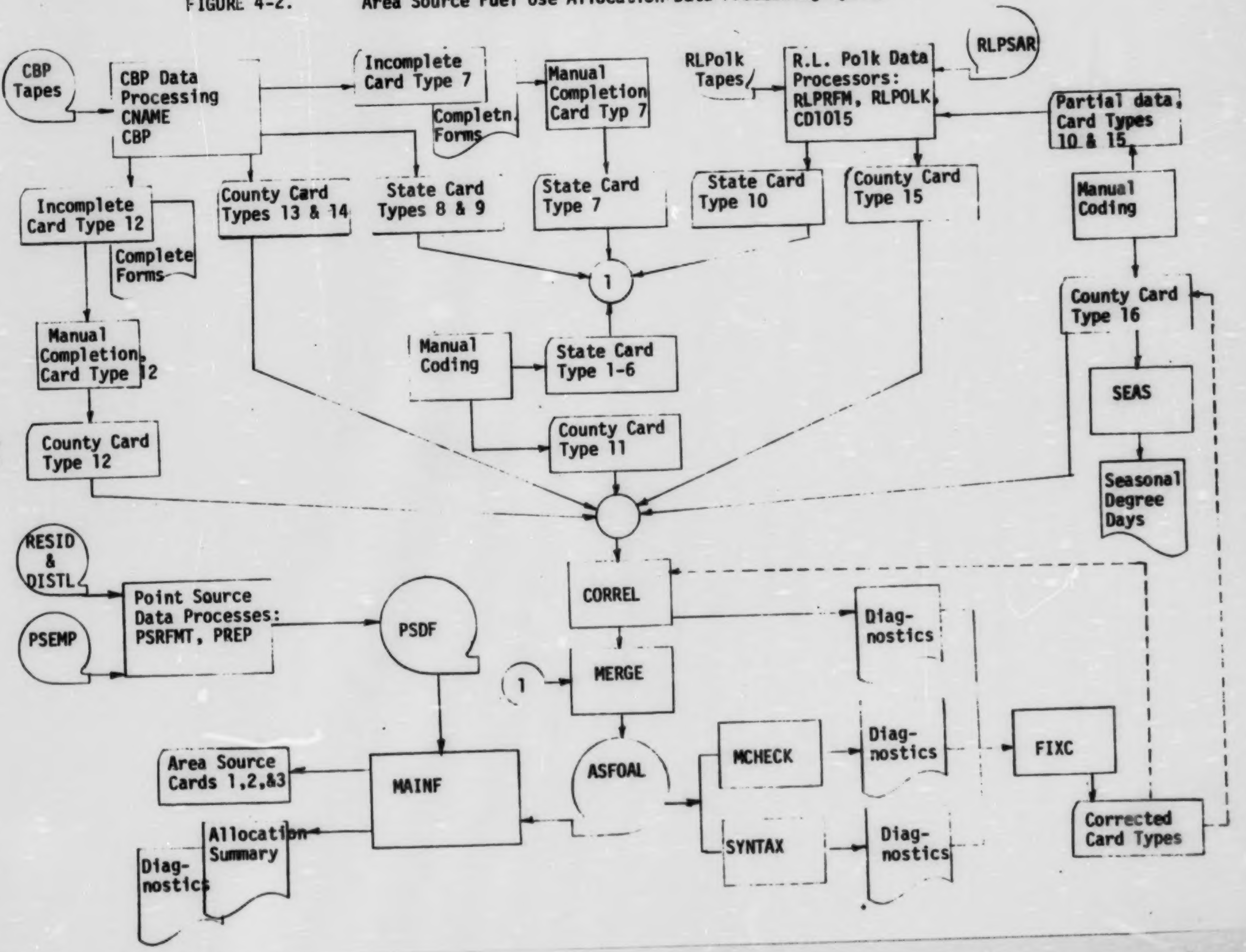
AIRCRAFT	Military LTO CYC 10^2	10–13
	Civil LTO CYC 10^1	14–19
	Commercial LTO CYC 10^1	20–24
VESSELS	Coal 10^1 tons	25–28
	Diesel Oil 10^6 Gals.	29–32
	Resid. Oil 10^6 Gals.	33–37
	Gasoline 10^3 Gals	38–41
EVAPORATION	Solvent Purchased tons yr	42–47
	Gasoline Marketed 10^5 Gals	48–52
MEASURED VEHICLE MILES	Limited Access Road 10^6 Miles	53–58
	Rural Roads 10^6 Miles	59–64
	Suburban Roads 10^6 Miles	65–70
	Urban Roads 10^6 Miles	71–77
Action		78
		79 A
cd		80 4

Dirt Roads Traveled 10^1 Vehicle miles		10–16
Dirt Air Strips LTO CYCLES		17–21
Construction Acres		22–27
Miscellaneous Wind Erosion 10^3 Acres		28–32
Land Tilling 10^3 Acres		33–37
FOREST WILDFIRES	Acres Burned	38–44
	Tons/acres Burned	45–47
MANAGED BURNING (Slash/Prescribed Burning)	Acres Burned	48–53
	Tons/Acres Burned	54–56
AGRICULTURAL FIELD BURNING	Acres Burned	57–62
	Tons/Acres Burned	63–65
FROST CONTROL 10^2	Orchard Heaters Operating	66–69
	Days/Fwd Days/year	70–72
STRUCTURE FIRES	Fires/year	73–77
Action		78
		79 A
cd		80 5

COMMENT		10–77
Action		78
		79 A
cd		80 6

EPA (Form) 219
3/72

FIGURE 4-2. Area Source Fuel Use Allocation Data Processing System


CBP Tapes
CBP Data Processing CNAME CBP
Incomplete Card Type 7
Completn. Forms
Manual Completion Card Typ 7
RLPolk Tapes
R.L. Polk Data Processors: RLPRFM, RLPOLK, CD1015
RLPSAR
Partial data, Card Types 10 & 15
Incomplete Card Type 12
Complete Forms
County Card Types 13 & 14
State Card Types 8 & 9
State Card Type 7
State Card Type 10
County Card Type 15
Manual Coding
1
Manual Completion, Card Type 12
Manual Coding
State Card Type 1-6
County Card Type 16
SEAS
County Card Type 12
County Card Type 11
Seasonal Degree Days
RESID & DISTL
Point Source Data Processes: PSRFMT, PREP
PSEMP
PSDF
CORREL
Diag-nostics
1
MERGE
Area Source Cards 1,2,&3
MAINF
ASFOAL
MCHECK
Diag-nostics
FIXC
Allocation Summary
Diag-nostics
SYNTAX
Diag-nostics
Corrected Card Types

B. THE AREA SOURCE FUEL ALLOCATION (ASFA) MASTER FILE

The data in the ASFA master file can be divided into three categories:

. National and regional level data
. State level data
. County level data

The data are stored in card image records according to the formats described in Table 4-1. Each record consists of an 8-digit key field in columns 1-8 and a data field in columns 9-80. The key field contains a 2-digit state SAROAD number, a 4-digit county SAROAD number, and a 2-digit card type number. For national and regional level records, the state and county numbers in the key field are coded as zero. For state level data, the county number in the key field is coded as zero. A list of data items on each record and their formats is contained in Table 4-1.

The format of the ASFA master file records will be referred to as "ASFA master file format."

The records are stored in the master file in ascending order according to the 8-digit key field. The structure of the ASFA master file resulting from this organization is illustrated below.

National and regional card types 1-99
State level card types 1-45 for SAROAD state 01
    County level card types 1-20 for first SAROAD county in state 01
    County level card types 1-20 for second SAROAD county in state 01
    .
    .
    .
    County level card types 1-20 for last SAROAD county in state 01
State level card types 1-45 for SAROAD state 02
    .
    .
    .

TABLE 4-1a

NATIONAL INPUT VARIABLES

Card Number	Description of Variables	Format*	Card Columns	Units
1	Industry sulfur content of coal, Production Districts 1-23	8X,23F3.1/	9-78	Percent
2	Other sulfur content of coal, Production Districts 1-23	8X,23F3.1/	9-78	Percent
3	Industry coal production, Production Districts 1-23	8X,23F3.0/	9-78	Tons x 10^5
4	Other coal production, Production Districts 1-23	8X,23F3.0/	9-78	Tons x 10^5
5	Ash content of bituminous coal, Production Districts 1-18	8X,18F4.2/	9-80	Percent
6	Ash content of bituminous coal, Production Districts 19-23	8X,5F4.2/	9-29	Percent
	Sulfur content of anthracite coal	F4.2	30-33	Percent
	Ash content of anthracite coal	F4.2	34-37	Percent
7	Annual usage of diesel tractors	8X,F3.0	9-11	Hours/Year
	Annual usage of gasoline tractors	F3.0	12-14	Hours/Year
	General purpose - agricultural	F3.0	15-17	Hours/Year
	Harvesters	F3.0	18-20	Hours/Year
	Balers	F3.0	21-23	Hours/Year
	Combines	F3.0	24-27	Hours/Year
	Average gasoline consumption rate, tractors	F3.2	28-30	Gallons/Year
	General purpose	F3.2	31-33	Gallons/Year
	Harvesters	F3.2	34-37	Gallons/Year
	Balers	F3.2	38-40	Gallons/Year
	Combines	F3.2	41-43	Gallons/Year

* The first 8 digits of each card contain the record identification key.

TABLE 4-1a (continued)

NATIONAL INPUT VARIABLES

Card Number	Description of Variables	Format *	Card Columns	Units
	Average diesel fuel consumption rate, tractors	F3.2	44-47	Gallons/Year
	General purpose	F3.2	48-50	Gallons/Year
	Harvesters	F3.2	51-53	Gallons/Year
	Balers	F3.2	54-57	Gallons/Year
	Combines	F3.2	58-60	Gallons/Year
	Percent tractors using gasoline fuel	F2.0	61-62	Percent
	Percent tractors using diesel fuel	F2.0	63-64	Percent
	Percent using gasoline, general purpose - agricultural	F2.0	65-66	Percent
	Harvesters	F2.0	67-68	Percent
	Balers	F2.0	69-70	Percent
	Combines	F2.0	71-72	Percent
8	Fuel consumption, construction, gasoline	8X,F7.0	9-15	Gallons x 10^3
	Fuel consumption, construction, diesel	F7.0	16-22	Gallons x 10^3
	Fuel consumption, industrial, gasoline	F7.0	23-29	Gallons x 10^3
	Fuel consumption, industrial, diesel	F7.0	30-36	Gallons x 10^3
	Fuel consumption, lawn and garden	F7.0	37-43	Gallons x 10^3
	Fuel consumption, snowthrowers	F7.0	44-50	Gallons x 10^3
	Fuel consumption, snowmobiles	F7.0	51-57	Gallons x 10^3
	Usage, motorcycles, off-road	F3.0	58-60	Miles/Year
	Usage (off-road), motorcycles, combination	F3.0	61-63	Miles/Year
	Gas mileage, motorcycles	F3.1	64-66	Miles/Gallon
	Gas mileage, inboard boats	F2.1	67-68	Gallons/Hour
	Gas mileage, outboard boats	F2.1	69-70	Gallons/Hour

---

* The first 8 digits of each card contain the record identification key.

TABLE 4-1a (continued)

NATIONAL INPUT VARIABLES

Card Number	Description of Variables	Format*	Card Columns	Units
9	Gas consumption by census region, cooking range	8X,9F3.0	9-35	Therms/Year
	Gas consumption by census region, water heater	9F3.0/	36-52	Therms/Year
10	Regional percentage, off-road motorcycles	8X,9F3.0	9-44	Percent
	Regional percentage, combination motorcycles	9F3.0/	45-80	Percent
11	Growth by census region in LPG heat	8X,9F4.1	9-44	Percent
	in LPG cooking	9F4.1	46-80	Percent
12	Growth by census region in coal heat	8X,14F4.0/	9-44	Percent
13	Solvent consumption	8X,14F5.0/	9-78	Pounds x 10^6
14	Solvent consumption	8X,3F5.0	9-23	Pounds x 10^6
	Bituminous coal consumption, steel mills	F5.0	24-28	Tons x 10^3
	Cement plants	F5.0	29-33	Tons x 10^3
	Other industrial	F5.0	34-38	Tons x 10^3
	Retail	F5.0/	39-43	Tons x 10^3
15	1971 Industrial coal consumption, SIC 20-29	8X,10F7.0/	9-78	Tons x 10^2
16	1971 Industrial coal consumption, SIC 30-38, 19 & 39	8X,10F7.0/	9-78	Tons x 10^2
17	1971 Industrial natural gas consumption, SIC 20-29	8X,10F7.0/	9-78	Ft.^{3} x 10^8
18	1971 Industrial natural gas consumption, SIC 30-38, 19 & 39	8X,10F7.0/	9-78	Ft.^{3} x 10^8
19	1971 Industrial employment, SIC 20-29	8X,10F7.0/	9-78	
20	1971 Industrial employment, SIC 30-38, 19 & 30	8X,10F7.0/	9-78	
21	Census year	8X, F4.0	9-12	
	Year before update year (or zero if no growth data)	F4.0	13-16	
	Update year	F4.0	17-20	
	University employment/enrollment ratio	F6.3	21-26	

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* The first 8 digits of each card contain the record identification key.

TABLE 4-1a (continued)

NATIONAL INPUT VARIABLES

Card Number	Description of Variables	Format*	Card Columns	Units
22	Solvent point source employment, SIC 25,26,27,30,34-38	8X,9F8.0/	9-80	
23	Solvent point source employment, SIC 39, Total 19-39, Laundries,243,244,371,373,7535	8X,9F8.0/	9-80	
24	Solvent point source employment, SIC 264,265	8X,2F8.0/	9-24	
REGIONAL INPUT				
25	Number of regional groupings	8X,I2/	*9-10	
26	Fuel index number for first regional grouping	8X,I2	11-12	
	Number of states in grouping	I2	13-14	
	Retail or residential fuel	F6.0	15-20	
	Commercial fuel	F6.0	21-26	
	Industrial fuel	F6.0	27-32	
	States in grouping (SAROAD numbers)	n I2 (n = number of states in grouping)		
27-99	Like 26, as many as needed, rest blank except for 8-digit key field in columns 1-8			

---

* The first 8 digits of each card contain the record identification key.

TABLE 4-1b

STATE INPUT VARIABLES

Card Number	Description of Variables	Format	Card Columns	Units
1	State SAROAD number	I2	1-2	
	Number of counties	6X,I3	8-10	
	State name	A14	11-24	
	Census region identifier	I2	25-26	
	Centroid county SAROAD number	I4	27-30	
	Coastline	F10.0	31-40	
	Coastline area factor	F10.3/	41-50	
2	Current employment, SIC 19-27	8X,9F8.0/	9-80	
3	Current employment, SIC 28-36	8X,9F8.0/	9-80	
4	Current employment, SIC 37-39	8X,3F8.0	9-32	
	Current employment, Total, 19-39	F8.0/	33-40	
5	Current employment, SIC 701 (hotels)	8X,F8.0	9-16	
	Current employment, SIC 7211+7216+7217 (laundries)	F8.0	17-24	
	Current employment, SIC 806 (hospitals)	F8.0	25-32	
	Current employment, SIC 821 (schools)	F8.0	33-40	
	Current employment, SIC 822 (universities)	F8.0	41-48	
	Current employment, SIC 60+70 minus above(other services)	F8.0	49-56	
	Current employment, SIC 50 (wholesale)	F.80	57-64	
	Current employment, SIC 52 (retail)	F8.0	65-72	
	Current employment, SIC 7215+2-7216+7218(laundries for solvents)	F3.0/	73-80	

TABLE 4-1b (continued)

STATE INPUT VARIABLES

Card Number	Description of Variables	Format	Card Columns	Units
6	Current employment, SIC 243 (millwork, plywood, etc.)	8X,F8.0	9-16	
	Current employment, SIC 244 (wooden containers)	F8.0	17-24	
	Current employment, SIC 371	F8.0	25-32	
	Current employment, SIC 373	F8.0	33-40	
	Current employment, SIC 7535	F8.0	41-48	
	Current employment, SIC 10--	F8.0	49-56	
	Current employment, SIC 16	F8.0	57-64	
	Current employment, SIC 264	F8.0	65-72	
	Current employment, SIC 265	F8.0/	73-80	
7	Employment data, SIC 19-27	8X,9F8.0/	9-80	
8	Employment data, SIC 28-36	8X,9F8.0/	9-80	
9	Employment data, SIC 37-39	8X,3F8.0	9-32	
	Employment data, SIC Total, 19-39	F8.0/	33-40	
10	Coal consumption data, SIC 19-27	8X,9F8.1/	9-80	Tons x 10^3
11	Coal consumption data, SIC 28-36	8X,9F8.1/	9-80	Tons x 10^3
12	Coal consumption data, SIC 37-39	8X,3F8.1	9-32	Tons x 10^3
	Coal consumption data, SIC Total, 19-39	F8.1/	33-40	Tons x 10^3
13	Gas consumption data, SIC 19-27	8X,9F8.1/	9-80	Ft.^{3} x 10^9
14	Gas consumption data, SIC 28-36	8X,9F8.1/	9-80	Ft.^{3} x 10^9
15	Gas consumption data, SIC 37-39	8X,3F8.1/	9-32	Ft.^{3} x 10^9

TABLE 4-1b (continued)

STATE INPUT VARIABLES

Card Number	Description of Variables	Format	Card Columns	Units
16	Coal shipments: retail total, retail production district groupings 1-13	8X,14F5.0/	9-78	Tons x 10^3
17	Retail total, retail production district groupings 14-20	8X,7F5.0	9-43	Tons x 10^3
	Industrial total, industrial production district groupings 1-6	7F5.0/	44-78	Tons x 10^3
18	Coal shipments: industrial production district groupings 7-20	8X,14F5.0/	9-78	Tons x 10^3
19	Public school employment	8X,F8.0	9-16	
	Hotel employee/room ratio	F8.2	17-24	
20	Current population	8X,F10.0	9-18	
21	Percent of gas customers with gas heat	8X,F6.1	9-14	Percent
	Additions to gas heating, each year since census year	11F6.1/	15-80	10^3 Additions
22	Conversions to gas heating, each year since census year	8X,11F6.1	9-74	10^3 Conversions
	Gas-heated dwelling units (previous year)	F6.0/	75-80	
23	Natural gas consumption, residential	8X,F8.0	9-16	Ft.^{3} x 10^6
	Industrial	F8.0	17-24	Ft.^{3} x 10^6
	Commercial	F8.0	25-32	Ft.^{3} x 10^6
	Other	F8.0	33-40	Ft.^{3} x 10^6
	LPG consumption, industrial	F8.0	41-48	Gallons x 10^3
	Retail	F8.0/	49-56	Gallons x 10^3
24	Anthracite coal shipments, retail	8X,F8.0	9-16	Tons
	Bituminous coal shipments, industrial	F8.0	17-24	Tons x 10^3
	Retail	F8.0	25-32	Tons x 10^3
	Anthracite market share	F8.2/	33-40	Percent

TABLE 4-1b (continued)

STATE INPUT VARIABLES

Card Number	Description of Variables	Format	Card Columns	Units
25	Gasoline consumption, highway	8X,F8.0	9-16	Gallons x 10^3
	Off-highway	F8.0	17-24	Gallons x 10^3
	Construction equipment	F8.0	25-32	Gallons x 10^3
	Commercial-industrial	F8.0	33-40	Gallons x 10^3
	Agricultural	F8.0	41-48	Gallons x 10^3
	Aviation	F8.0	49-56	Gallons x 10^3
	Railroad use of diesel fuel	F8.0/	57-63	Bbl x 10^3
26	Registrations, motorcycles	8X,F8.0	9-16	
	Snowmobiles	F8.0	17-24	
	Inboard boats	F8.0	25-32	
	Outboard boats	F8.0/	33-40	
27	Farms in irrigated areas	8X,F8.0	9-16	
	Tractors	F8.0	17-24	
	Combines	F8.0	25-32	
	Harvesters (corn huskers)	F8.0	33-40	
	Pickup balers	F8.0	41-48	
28	Census year population	8X,F9.0	9-17	
	Gas-heated dwelling units	F8.0	18-25	
	Coal-heated dwelling units	F8.0	26-33	
	Elementary and kindergarten enrollment	F8.0	34-41	
	High school enrollment	F8.0/	42-49	

TABLE 4-1b (continued)

STATE INPUT VARIABLES

Card Number	Description of Variables	Format	Card Columns	Units
POINT SOURCE DATA				
29	Point source employment, SIC 19-27	8X,9F8.0/	9-80	
30	Point source employment, SIC 28-36	8X,9F8.0/	9-80	
31	Point source employment, SIC 37-39	8X,3F8.0	9-32	
	Total, SIC 19-39	F8.0/	33-40	
32	Point source employment, SIC 701, (7211+7216+7217), 806,821,822,other sources, 50,52,(7215+2x7216+7218)	8X,9F8.0/	9-80	
33	Point source employment, SIC 243,244,371,373,7535, 10,16,264,265	8X,9F8.0/	9-80	
34	Bituminous coal, commercial consumption	8X,F8.0	9-16	Tons
	Sulfur content	F8.0	17-24	Tons
	Ash content	F8.0	25-32	Tons
	Bituminous coal, industrial consumption	F8.0	33-40	Tons
	Sulfur content	F8.0	41-48	Tons
	Ash content	F8.0	49-56	Tons
	Natural gas consumption, commercial,	F8.0	57-64	Ft.^{3} x 10^6
	Industrial (including LPG)	F8.0	65-72	Ft.^{3} x 10^6
	LPG consumption, commercial	F8.0/	73-80	Gallons x 10^3
35	Anthracite coal consumption, commercial	8X,F8.0/	9-16	Tons
36-45	Blank			

TABLE 4-1c

COUNTY INPUT VARIABLES

Card Number	Description of Variables	Format	Card Columns	Units
1	County SAROAD number	2X,I4	3-6	
	AQCR	2X,I3	9-11	
	County name	A26	12-37	
	Degree days	F6.0	38-43	
	Number of days with temperature less than 32°F	F3.0	44-46	
	Number of "warm" months	F2.0	47-48	
	Snowfall	F9.0/	49-57	10^{-2} Inches
2	Current employment, SIC 19-27	8X,9F8.0/	9-80	
3	Current employment, SIC 28-36	8X,9F8.0/	9-80	
4	Current employment, SIC 37-39	8X,3F8.0	9-32	
	Total, 19-39	F8.0/	33-40	
5	Current employment, SIC 701 (hotels)	8X,F8.0	9-16	
	SIC 7211+7216+7217 (commercial laundries)	F8.0	17-24	
	SIC 806 (hospitals)	F8.0	25-32	
	SIC 821 (schools)	F8.0	33-40	
	SIC 822 (universities)	F8.0	41-48	
	SIC 60+70 minus above (other services)	F8.0	49-56	
	SIC 50 (wholesale)	F8.0	57-64	
	SIC 52 (retail)	F8.0	65-72	
	SIC 7215+2x7216+7218 (laundries for solvents)	F8.0/	73-80	

TABLE 4-1c (continued)

COUNTY INPUT VARIABLES

Card Number	Description of Variables	Format	Card Columns	Units
6	Current employment, SIC 243 (millwork, plywood, etc.)	8X,F8.0	9-16	
	SIC 244 (wooden containers)	F8.0	17-24	
	SIC 371 (motor vehicles & equipment)	F8.0	25-32	
	SIC 373 (ship & boat building & repair)	F8.0	33-40	
	SIC 7535 (paint stores)	F8.0	41-48	
	SIC 10 (mining)	F8.0	49-56	
	SIC 16 (heavy construction)	F8.0	57-64	
	SIC 264 (miscellaneous connected paper products)	F8.0	65-72	
	SIC 365 (paper board containers & boxes)	F8.0/	73-80	
7	Hospital beds	8X,F8.0	9-16	
	Hospital employment	F8.0	17-24	
	Public university enrollment	F8.0/	25-32	
8	Population density	8X,F9.0	9-17	
	Kindergarten and elementary enrollment	F9.0	18-26	
	High school enrollment	F9.0	27-35	
	Year-round housing units	F9.0	36-44	
	Median rooms per dwelling units (÷10)	F9.1	45-53	
	% rooms in 1-unit simultaneous (÷10)	F9.1	54-62	Percent
	Farms	F9.0	63-71	
	Farms with sales ≥ $2500	F9.0/	72-80	
9	Census year population	8X,F8.0	9-16	
	Number of occupied dwelling units	F8.0	17-24	

TABLE 4-1c (continued)

COUNTY INPUT VARIABLES

Card Number	Description of Variables	Format	Card Columns	Units
10	Number of occupied dwelling units with gas heat	8X,F8.0	9-16	
	Number of occupied dwelling units with LPG heat	F8.0	17-24	
	Number of occupied dwelling units with oil heat	F8.0	25-32	
	Number of occupied dwelling units with coal heat	F8.0	33-40	
	Number of occupied dwelling units with natural gas ranges	F8.0	41-48	
	Number of occupied dwelling units with LPG ranges	F8.0	49-56	
	Number of occupied dwelling units with natural gas hot water	F8.0	57-64	
	Number of occupied dwelling units with LPG hot water	F8.0/	65-72	
11	Current population	8X,F8.0	9-16	
	Tractors	F8.0	17-24	
	Gross revenues of service stations or retail gasoline consumption	F8.0/	25-32	\$ or (Gallons x 10^3)
12	Air carrier and taxi operations	8X,F8.0	9-16	
	General aviation operations	F8.0	17-24	
	Military	F8.0	25-32	
	Aircraft registrations	F8.0/	33-40	
13	Inland water area	8X,F10.0	9-18	
	Coastline	F10.0/	19-28	
14	Point source employment, SIC 19-27	8X,9F8.0	9-80	
15	Point source employment, SIC 28-36	8X,9F8.0	9-80	
16	Point source employment, SIC 37-39	8X,3F8.0	9-32	
	Point source employment, Total 19-39	F8.0	33-40	

TABLE 4-1c (continued)

COUNTY INPUT VARIABLES

Card Number	Description of Variables	Format	Card Columns	Units
17	Point source employment, SIC 701,(7211+7216+7217), 806,821,822,other services,50,52, (7215+2x7216+7218)	8X,9F8.0/	9-80	
18	Point source employment, SIC 243,244,371,373,7535, 10,16,264,265	8X9F8.0/	9-80	
19	Point source employment, for solvents, SIC 25-27,30, 34-38	8X,9F8.0/	9-80	
20	Point source employment, for solvents, SIC 39	8X,F8.0/	9-16	

State level card types 1-45 for SAROAD state 52
    County level card types 1-20 for first SAROAD county in state 52
    .
    .
    .
    County level card types 1-20 for last SAROAD county in state 52

C. THE ASFA PREPROCESSING SYSTEM

The ASFA preprocessing system is conducted in two steps: update file generation and ASFA master file updating. There are two types of update files that are generated by the ASFA preprocessing system. One type is a file of records in the ASFA master file format that will **replace** the corresponding records on the existing ASFA master file. The second type is the format required by the NOAA UPD8 program for updating the climatological data stored on ASFA master file county card type 1.

1. Update File Generation

The update file generation is functionally grouped into seven categories:

- National Oceanographic and Atmospheric Administration (NOAA) Data Processing
- Census of Housing Data Processing
- County and City Data Book Data Processing
- County Business Patterns (CBP) Data Processing
- NEDS Point Source Data Processing
- Manual Coding and Keypunching
- Card Processing

The flow diagram in Figure 4-2 depicts the interrelationship of these sets and their interaction with the ASFA master file. Each stage can be performed independently of the others. As the necessary input files for each stage become available, processing of these files can be initiated. The resultant output from each stage is an update file that can be entered into the ASFA master file by the appropriate update program.

a. NOAA Data Processing

Three programs are used to: (1) extract a set of climatological data for each weather station, (2) replace missing data items with the corresponding data items from the nearest weather station in the same climatological district, and (3) assign the data items to the appropriate county. A fourth program is used to load the NOAA data onto the master file.

Three input tapes are processed by this set of preprocessing programs. The data extracted from these tapes include the following:

- Station latitude and longitude by station number
- Degree days, snowfall, number of days with the temperature less than 32°F, and the number of months with the mean temperatures greater than a predetermined temperature which is a function of the latitude of the station
- SAROAD county number and the corresponding NOAA station number

b. CBP Data Processing

Three preprocessing program are used to process the CBP data. The CBP data are in a continuous file contained in four tapes. Employment data are extracted for a number of SIC codes which correspond to the various industrial and commercial categories used in the allocations. The county code must be converted from the CBP code to the corresponding SAROAD codes, and the data for the appropriate SIC codes must be extracted and summed by county before transferring it into the master file.

c. Census of Housing Data Processing

Three preprocessing programs are used for processing the Census of Housing data. The data extracted from the Census of Housing tape include: (1) total number of occupied dwelling units, (2) number of dwelling units distributed by fuel use, and (3) number of dwelling units using natural gas and LPG for cooking as well as for hot water. These data must be assigned to the corresponding SAROAD county and state numbers and summed by county prior to entry onto the master file.

d. County and City Data Book Data Processing

Two programs are used to process the county and city data book tape. The first program reformats the input tape into card images, retaining only required data items. The second stage reads the card images, converts the GSA/FIPS state and county codes to SAROAD equivalents, and outputs the following data items, viz.:

- Total number of farms
- Number of farms in class 1-5
- Median rooms per housing unit
- Enrollment in primary schools for age group 3-34
- Enrollment in secondary schools for age group 3-34
- Number of dwelling units which are single-unit structures

e. NEDS Point Source Data Processing

Two magnetic tapes contain the required point source data items for updating the ASFA master file. The NEDSPS tape contains all data items on the NEDS point source coding form for each point source. The PSEMP tape contains point source employment by SIC category.

Two programs are necessary to process the two tapes and generate the required ASFA master file point source data records. One program extracts the fuel use and sulfur and ash content data from the NEDSPS tape and outputs the data on a card image file. The second program reads the reformatted fuel use tape and employment data tape and generates the ASFA master file point source data records.

f. Manual Coding and Keypunching

The manual coding effort required in the ASFA preprocessing system can be delineated into five categories:

- National and regional data card types 1-99
- State card types 7-27
- County card type 11
- Input to card processing program (see Section II.B.1.g)
- Revisions resulting from the review of diagnostic files output by various preprocessors or the update program

Input requirements for the card processing programs are described in the documentation for these programs [1].

Diagnostic files output by the NOAA, CBP, CENSUS, and county and city data book data processing programs consist of lists of data which could not be matched with a SAROAD county. These diagnostic messages require manual review and edit. The review should consist of determining the SAROAD county to which the data correspond. The complete data for that SAROAD county required for updating the particular ASFA master file record must be coded and keypunched for input to the master file update program.

g. Card Processing

The data required for ASFA master file county card types 7 and 12 cannot be coded directly from the source documents. The data are identified in various documents by county name, but are listed by individual institution. The data must, therefore, be assigned to the appropriate SAROAD county, and county totals must be computed. Five programs have been written to process the data after they have been keypunched on cards. Three of the programs are involved in reduction of university enrollment, hospital beds, and hospital employment data by SAROAD county and generating ASFA master file county card type 7. The other two programs process the aircraft registration and FAA aircraft operations data by SAROAD county and generate ASFA master file county card type 12.

2. Updating the ASFA Master File

ASFA master file updating consists of generating an updated version of the master file by replacing the data on the existing master file with the corresponding data items in the current update files. The update files created by the programs described in Sections IV.B.1.b-g are all processed by the UPD8 program. These update files can be processed individually or combined with any other of these update tiles. The NOAA update file (Section IV.b.1.a) must be treated exclusively, using a different update program. Output from the update programs consists of an updated ASFA master file, a list of invalid keys detected, and a disk file containing the records with invalid keys. The invalid key file must be reviewed and edited, and the corrected records must be entered onto the master file in a subsequent update. When all required update files have been entered onto the master file and all invalid keys resolved, the master file is ready for input to the ASFAP program.

D. THE AREA SOURCE FUEL ALLOCATION PROGRAM (ASFAP)

The general structure of the ASFAP program is illustrated in Figure 4-3. This program applies the allocation methodologies to the data on the ASFA master file and outputs a set of fuel use data by county for upgrading the corresponding items in the NEDS area source data bank. ASFAP is comprised of a main program and twelve subroutines. The main program is responsible for reading in control cards and master file data and for passing control to the various subroutines in the proper sequence. The individual subroutines perform the allocation calculations and output the results. A list of the subroutines and a brief description of the function of each is given in Table 4-2.

The main program consists of two state loops, each with a nested county loop. Prior to the first state loop, arrays are initialized, control cards are read, and the national and regional level data are read in from the master file. During the pass through the first state and county loops, the entire master file is read, but only desired states, as indicated in the input control cards, are processed. However, certain items are required from data for each state and county for computing national totals. For states that are to be processed, various levels of processing for each methodology are performed by passing control to the appropriate subroutine. The intermediate calculations for these states and counties are output to temporary disk files.

In the pass through the second state and county loops, the intermediate calculations are read in from temporary disk, the allocation methodologies are completed, and the county fuel use estimates are normalized to state totals. As the processing for each state is completed, the allocation results are output to a print file in summary tables and to a card image file according to NEDS format specifications. Of the six area source cards associated with each county, only card types 1, 2, 3, and 4 are affected. The results of the various allocation methodologies will appear in the darkened fields shown in the card layouts in Figure 4-1.

FIGURE 4-3. ASFAP Program Flow Chart

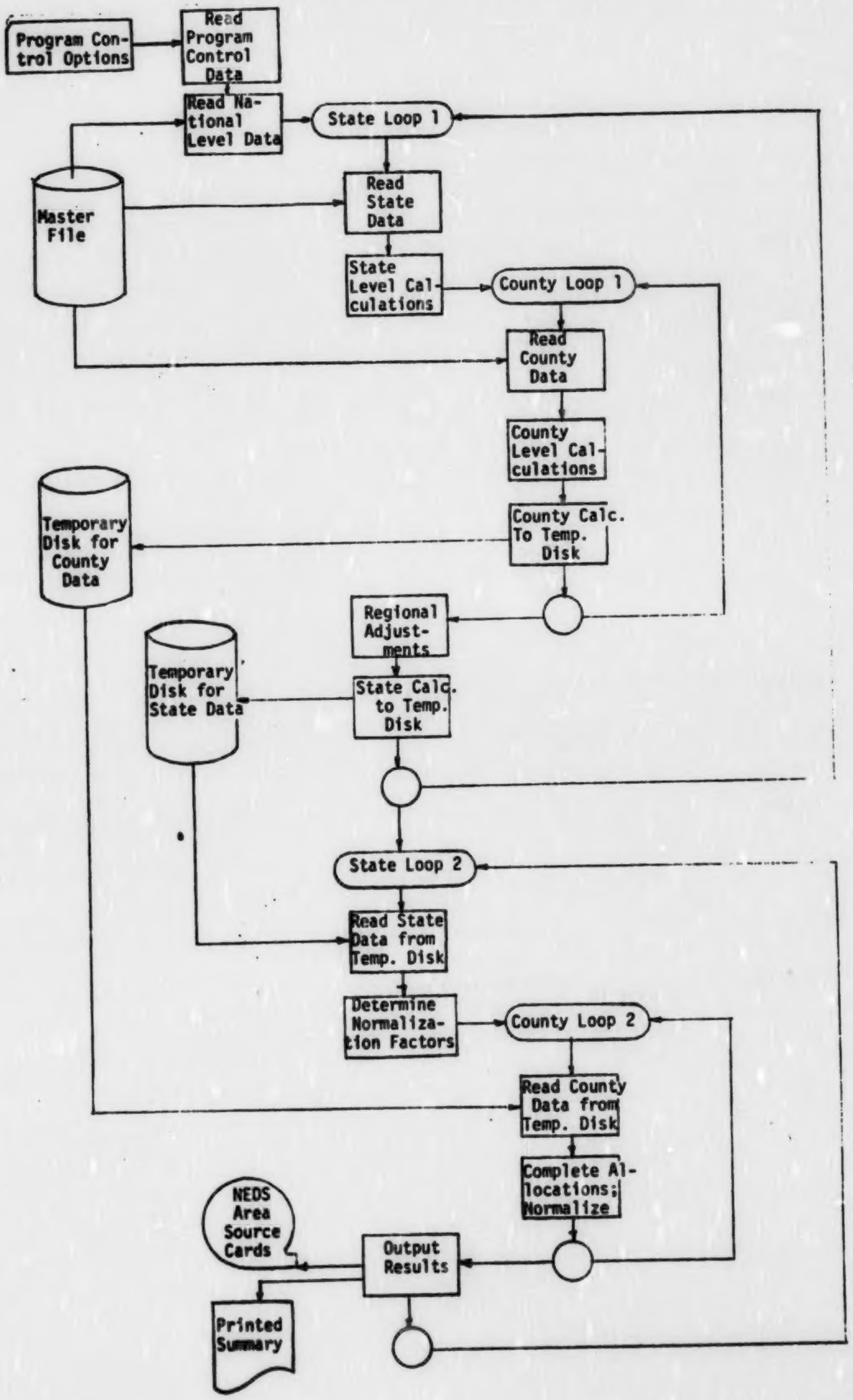
Program Control Options
Read Program Control Data
Read National Level Data
State Loop 1
Master File
Read State Data
State Level Calculations
County Loop 1
Read County Data
County Level Calculations
Temporary Disk for County Data
County Calc. To Temp. Disk
Regional Adjustments
Temporary Disk for State Data
State Calc. to Temp. Disk
State Loop 2
Read State Data from Temp. Disk
Determine Normalization Factors
County Loop 2
Read County Data from Temp. Disk
Complete Allocations; Normalize
NEDS Area Source Cards
Output Results
Printed Summary

TABLE 4-2

ASFAP SUBROUTINES

Subroutine Name	General Description of Subroutine Function
AREAS	Compute area source employment and consumption by subtracting NEDS point source data from corresponding totals
COM	Perform methodology for allocating commercial use of natural gas, anthracite coal, and bituminous coal
INDUST	Perform methodology for allocating industrial use of natural gas and bituminous coal
LTO	Allocate military, civil, and commercial LTO cycles to counties
OFFHWY	Perform methodology for allocating use of gasoline and diesel fuels by off-highway sources
PRINT	Print allocation results and punch output for NEDS ASDB update
PRMAST	Print master file input
RES	Perform methodology for allocating residential use of natural gas, anthracite coal, and bituminous coal
RETGAS	Perform methodology for allocating retail gasoline sales
RRVESL	Perform methodologies for allocating railroad use of diesel fuel and gasoline consumption by vessels
SOLVNT	Perform methodology for allocating organic solvents
SULASH	Perform methodology for allocating sulfur and ash content of anthracite coal and bituminous coal

Diagnostic messages associated with either input data or intermediate computation are output on a separate print file for further investigation. A more detailed description of the program is given in the program documentation report [1].

E. RESULTS FOR SELECTED TEST COUNTIES

Output from the main allocation program (ASFAP) required verification to ensure that all methodologies were being performed properly. Thirteen counties were selected for performing hand calculations which would be checked against the computer program results. Several modifications to the ASFAP program were made before all test requirements were fulfilled, and all program test results agreed with the manual calculations. A summary of the results from the final test run of the ASFAP program are contained in this section.

1. Selection Criteria

A total of thirteen counties was selected for testing of the computer programs developed to implement the allocation methodologies. Because the allocation methodologies are generally based on the use of socioeconomic, demographic, and climatological variables to apportion statewide fuel consumption to the individual counties, extremities in these variables provide a meaningful base to develop criteria for selecting test candidate counties.

These criteria were translated into the following set of factors which were considered in selecting the candidate test counties:

- Total county population
- Degree of urbanization, as measured by the population density
- Predominance of specific type(s) of land use, e.g., heavy industrial activity or agricultural activity
- High level of employment in service industries, i.e., commercial/institutional use category
- Average annual degree days
- Fuel preference or the predominance of a fuel type
- Extreme amount of inland water area and/or length of coastline
- Absence of either FAA regulated or military airport

- Population growth rates which are high or negative
- Amount of snowfall
- Complicated geographical or political unit

In addition to data considerations, a complete state had to be tested in order to test normalization procedures. Because of the extremely large amount of processing required for each county, Delaware, which contains only three counties, was selected for testing normalization procedures.

A list of the selected test counties and a summary of the demographic and climatological data used in the testing (and the 1973 update) are listed in Table 4-3.

2. Summary of County Results

Table 4-4 shows the residential consumption of anthracite coal, bituminous coal, natural gas, and LPG for the thirteen counties, as computed by the methodologies described in Section II.A.1. The total gas equivalent given in the last column represents the sum of natural gas and the term equivalent of natural gas from the LPG consumption.

Estimated consumption of these four fuels is also compiled for commercial/institutional use. The results are shown in Table 4-5. These consumptions refer only to area source use, since point source fuel use has also been subtracted from statewide fuel use totals and corresponding point source employment figures have been subtracted from reported county level employment figures.

Industrial use of coal and gas is given in Table 4-6. These consumption figures refer to area sources only, since point source contributions were excluded in a manner similar to the commercial/institutional category. No anthracite use is assumed for industrial area sources. The natural gas equivalent of LPG was added to state residential natural gas consumption prior to the allocation.

Weighted sulfur and ash contents in coal for the county are given in Table 4-7. The sulfur and ash contents are reported in percentages for both anthracite and bituminous coal.

TABLE 4-3

SUMMARY OF DEMOGRAPHIC AND CLIMATOLOGICAL CHARACTERISTICS FOR CANDIDATE COUNTIES FOR TESTING OF METHODOLOGY

County Name	Population	Population Density Per Sq. Mile	% Population Change 1960-1970	% Labor Force In Manufacturing	% Labor Force In Services	% Dwelling Units In One-Unit Structures	% of Land In Farms	1971-1972 Degree Days
Bristol Bay Division, Alaska	1,045	2	(NA)	0	3.0	67.8	(NA)	12,888
Los Angeles, California	7,036,463	1,730	16.6	27.3	9.1	60.6	21.4	1,193
Kent, Delaware	81,892	138	35.9	24.6	6.2	69.8	57.8	3,945
Newcastle, Delaware	385,856	883	35.7	30.5	8.6	74.8	40.4	4,166
Sussex, Delaware	81,353	85	8.8	30.2	6.3	83.2	56.1	4,340
District of Columbia	765,510	12,402	-1.0	4.9	12.6	36.8	0	3,927
Honolulu, Hawaii	629,176	1,058	26.0	10.3	9.5	58.8	38.5	0
Ness, Kansas	4,791	4	-12.4	1.9	5.2	93.6	100.6	4,935
Metropolitan Boston, Massachusetts								5,532
Coos, New Hampshire	34,291	19	-7.7	43.6	6.4	61.2	7.6	9,312
New York, New York	1,539,233	66,923	-9.4	18.1	13.4	1.1	0	4,684
Schuylkill, Pennsylvania	160,089	204	-7.5	45.5	4.5	80.8	20.0	6,913
Jefferson, Texas	244,817	259	0.3	28.2	9.3	85.8	57.5	1,150
National Average or Total	203,212,877	57	13.3	25.9	7.7	69.1	47.0	

TABLE 4-4

FUEL USE AND ACTIVITY BY COUNTY 1973

RESIDENTIAL

County Name	Coal (Tons)			LPG	Gas (Ft.^{3} x 10^6)	
	Bituminous	Anthracite	Total	(Kilgal.)	Natural	Total Gas Equivalent
Bristol Bay Division, Alaska	0.0	0.0	0.0	0.404E+01	0.0	0.373E+00
Los Angeles, California	0.0	0.0	0.0	0.181E+05	0.180E+06	0.182E+06
Kent, Delaware	0.550E+02	0.495E+03	0.550E+03	0.266E+04	0.476E+03	0.721E+03
Newcastle, Delaware	0.636E+03	0.572E+04	0.636E+04	0.354E+04	0.690E+04	0.723E+04
Sussex, Delaware	0.211E+03	0.190E+04	0.211E+04	0.538E+04	0.138E+03	0.634E+03
District of Columbia	0.439E+05	0.535E+04	0.512E+05	0.174E+05	0.195E+05	0.211E+05
Honolulu, Hawaii	0.0	0.0	0.0	0.188E+04	0.0	0.173E+04
Ness, Kansas	0.0	0.0	0.0	0.135E+04	0.124E+03	0.249E+03
Metropolitan Boston, Massachusetts	0.995E+04	0.517E+04	0.151E+05	0.123E+05	0.363E+05	0.374E+05
Coos, New Hampshire	0.586E+01	0.537E+02	0.596E+02	0.509E+03	0.332E+01	0.577E+02
New York, New York	0.343E+05	0.114E+06	0.148E+06	0.843E+04	0.125E+05	0.133E+05
Schuylkill, Pennsylvania	0.208E+05	0.188E+06	0.208E+06	0.252E+04	0.127E+03	0.359E+03
Jefferson, Texas	0.0	0.0	0.0	0.268E+04	0.528E+04	0.553E+04

TABLE 4-5

FUEL USE AND ACTIVITY BY COUNTY 1973

COMMERCIAL/INDUSTRIAL

County Name	Coal (Tons)			LPG	Gas (Ft.^{3} x 10^6)	
	Bituminous	Anthracite	Total	(Kilogal.)	Natural	Total Gas Equivalent
Bristol Bay Division, Alaska	0.0	0.0	0.0	0.0	0.0	0.0
Los Angeles, California	0.0	0.0	0.0	0.566E-02	0.873E+05	0.873E+05
Kent, Delaware	0.162E+02	0.195E+03	0.212E+03	0.104E+04	0.194E+03	0.290E+03
Newcastle, Delaware	0.189E+03	0.228E+04	0.247E+04	0.247E+04	0.290E+04	0.313E+04
Sussex, Delaware	0.499E+02	0.603E+03	0.653E+03	0.243E+04	0.556E+04	0.280E+03
District of Columbia	0.0	0.771E-02	0.771E-02	0.0	0.879E+04	0.879E+04
Honolulu, Hawaii	0.0	0.0	0.0	0.862E+04	0.0	0.794E+03
Ness, Kansas	0.0	0.0	0.0	0.680E+03	0.773E+02	0.140E+03
Metropolitan Boston, Massachusetts	0.0	0.384E-03	0.384E-03	0.593E-02	0.212E+05	0.212E+05
Coos, New Hampshire	0.221E-05	0.462E-04	0.485E-03	0.443E+03	0.529E+01	0.465E+02
New York, New York	0.0	0.793E-01	0.793E-01	0.534E-02	0.101E+05	0.101E+05
Schuylkill, Pennsylvania	0.252E+05	0.507E+05	0.758E+05	0.0	0.453E+02	0.453E+02
Jefferson, Texas	0.0	0.0	0.0	0.129E+04	0.388E+04	0.400E+04

TABLE 4-6

FUEL USE AND ACTIVITY BY COUNTY 1973

INDUSTRIAL

County Name	Bituminous Coal (Tons)	Total Gas Equivalent (Ft.^{3} x 10^6)
Bristol Bay Division, Alaska	0.0	0.0
Los Angeles, California	0.0	0.239E+06
Kent, Delaware	0.199E+03	0.142E+03
Newcastle, Delaware	0.830E+04	0.266E+04
Sussex, Delaware	0.633E+03	0.260E+03
District of Columbia	0.0	0.506E+04
Honolulu, Hawaii	0.0	0.206E+03
Ness, Kansas	0.0	0.0
Metropolitan Boston, Massachusetts	0.0	0.751E+04
Coos, New Hampshire	0.203E+02	0.119E+02
New York, New York	0.105E+06	0.892E+04
Schuylkill, Pennsylvania	0.0	0.173E+04
Jefferson, Texas	0.428E+01	0.161E+06

TABLE 4-7

SULFUR AND ASH IN COAL BY COUNTY 1973

County Name	Anthracite (%)		Bituminous (%)	
	Sulfur	Ash	Sulfur	Ash
Bristol Bay Division, Alaska	0.0	0.0	0.0	0.0
Los Angeles, California	0.0	0.0	0.0	0.0
Kent, Delaware	0.660E+00	0.112E+02	0.151E+01	0.999E+01
Newcastle, Delaware	0.660E+00	0.112E+02	0.162E+01	0.104E+02
Sussex, Delaware	0.660E+00	0.112E+02	0.149E+01	0.991E+01
District of Columbia	0.660E+00	0.112E+02	0.802E+00	0.736E+01
Honolulu, Hawaii	0.0	0.0	0.0	0.0
Ness, Kansas	0.0	0.0	0.0	0.0
Metropolitan Boston, Massachusetts	0.660E+00	0.112E+02	0.807E+00	0.735E+01
Coos, New Hampshire	0.660E+00	0.112E+02	0.164E+01	0.891E+01
New York, New York	0.660E+00	0.112E+02	0.196E+01	0.101E+02
Schuylkill, Pennsylvania	0.660E+00	0.112E+02	0.160E+01	0.105E+02
Jefferson, Texas	0.0	0.0	0.293E+01	0.109E+02

Results of countywide transportation fuel use and activity estimates are shown in Table 4-8. The data reported are off-highway consumption of gasoline and diesel fuel; vessels' use of gasoline; railroad use of diesel; and aircraft LTOs distributed according to commercial, civil, and military categories.

Countywide retail gasoline sales and organic solvent consumption are reported in Table 4-9 as evaporation losses. The solvent consumption is disaggregated into special naphthas and all other solvents. Further distribution of the special naphthas and the total solvents according to the twelve sub-categories of surface coasting applications and the six primary categories of solvent users is given in Table 4-10. Each column heading in this table lists two solvent user categories. For each county, two rows of values are listed for special naphthas and two rows are listed for total solvents. In each case, the first row of values correspond to the user categories in the first row of column headings; the second row of values correspond to the user categories in the second row of column headings.

3. Summary of Sample State Results

The countywide results given in Table 4-11 are available for all counties in the United States for 1973 in the form of a computer printout and NEDS area source punched cards provided to EPA-NADB, Durham, North Carolina. Unlike the above presentation, the county results in the national processing are aggregated on a state-by-state basis. Additionally, a fuel use and activity summary for each state is also presented. An example of the state summary is given in Table 4-11, showing results for the state of Delaware.

TABLE 4-8

FUEL USE AND ACTIVITY BY COUNTY 1973

TRANSPORTATION

County Name	Gasoline (Kilogal.) Off-Highway	Gasoline (Kilogal.) Vessels	Diesel (Kilogal.) Off-Highway	Diesel (Kilogal.) Railroads	Aircraft LTOs Com.(10S)	Aircraft LTOs Civ.(10S)	Aircraft LTOs Mil.(100S)	Aircraft LTOs Total(10S)
Bristol Bay Division, Alaska	0.592E+03	0.136E+02	0.196E+02	0.143E+02	573.5	671.6	14.8	1,393.0
Los Angeles, California	0.225E+07	0.350E+04	0.190E+06	0.121E+06	23,530.0	90,480.0	360.7	117,600.0
Kent, Delaware	0.110E+05	0.824E+03	0.463E+04	0.197E+03	0.0	222.5	334.0	3,562.0
Newcastle, Delaware	0.456E+05	0.104E+04	0.171E+05	0.875E+07	753.3	7,411.0	139.0	9,554.0
Sussex, Delaware	0.114E+05	0.234E+04	0.540E+04	0.188E+03	0.0	3,769.0	0.0	3,796.0
District of Columbia	0.432E+05	0.395E+04	0.224E+05	0.630E+04	12,910.0	4,031.0	75.2	17,700.0
Honolulu, Hawaii	0.105E+06	0.0	0.221E+05	0.0	7,253.0	21,410.0	2,093.0	49,590.0
Ness, Kansas	0.260E+04	0.0	0.755E+03	0.199E+03	0.0	292.0	0.0	292.0
Metropolitan Boston, Massachusetts	0.197E+06	0.490E+04	0.714E+05	0.128E+05	0.0	1,333.0	255.1	3,884.0
Coos, New Hampshire	0.566E+04	0.269E+03	0.105E+04	0.542E+01	0.0	1,059.0	0.0	1,059.0
New York, New York	0.818E+05	0.200E+03	0.476E+05	0.675E+04	0.0	1,497.0	0.0	1,497.0
Schuylkill, Pennsylvania	0.258E+05	0.500E+01	0.535E+04	0.195E+04	0.0	2,701.0	0.0	2,701.0
Jefferson, Texas	0.540E+05	0.111E+04	0.119E+05	0.105E+05	772.9	4,693.0	33.6	5,803.0

TABLE 4-9

FUEL USE AND ACTIVITY BY COUNTY 1973

EVAPORATION LOSSES

County Name	Retail Gasoline Sales (Kilogal.)	Solvents (Tons)		
		Special Naphthas	Other Solvents	Total
Bristol Bay Division, Alaska	0.293E+03	0.242E+02	0.129E+02	0.371E+02
Los Angeles, California	0.337E+07	0.293E+06	0.209E+06	0.501E+06
Kent, Delaware	0.637E+05	0.209E+04	0.119E+05	0.326E+04
Newcastle, Delaware	0.207E+06	0.831E+04	0.512E+05	0.134E+05
Sussex, Delaware	0.397E+05	0.181E+04	0.104E+05	0.285E+04
District of Columbia	0.258E+06	0.243E+05	0.113E+05	0.356E+05
Honolulu, Hawaii	0.222E+06	0.105E+05	0.609E+04	0.166E+05
Ness, Kansas	0.266E+04	0.561E+02	0.307E+02	0.868E+02
Metropolitan Boston, Massachusetts	0.121E+07	0.815E+05	0.579E+05	0.139E+06
Coos, New Hampshire	0.161E+05	0.483E+03	0.252E+03	0.734E+03
New York, New York	0.172E+06	0.927E+05	0.492E+05	0.142E+06
Schuylkill, Pennsylvania	0.787E+05	0.527E+04	0.353E+04	0.881E+04
Jefferson, Texas	0.146E+06	0.659E+04	0.442E+04	0.110E+05

TABLE 4-10

SOLVENTS BY USER CATEGORY

	Trade Paint SIC 36	Total Man. SIC 7535	Marine SIC 371	Surface Coating SIC 25	Degreasing SIC 34	Dry Cleaning SIC 35 & 36	Printing SIC 26	Rubber SIC 243&244	Transportation Other Users
110 Bristol Bay Div., Alaska	0.1628E+01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Special Naphthas	0.0	0.1709E+01	0.0	0.3337E+01	0.0	0.0	0.0	0.0	0.1755E+02
	0.2632E+01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Solvents	0.0	0.2764E+01	0.0	0.5396E+01	0.0	0.0	0.0	0.0	0.2633E+02
4200 Los Angeles, California	0.1028E+05	0.7079E+03	0.3052E+04	0.1263E+05	0.6223E+04	0.5270E+04	0.2297E+04	0.7719E+03	0.2329E+05
Special Naphthas	0.1310E+04	0.1097E+05	0.7591E+03	0.7755E+05	0.0	0.1080E+05	0.1485E+05	0.0	0.1119E+06
	0.1662E+05	0.1145E+04	0.4936E+04	0.2042E+05	0.1006E+04	0.3714E+04	0.1248E+04	0.1248E+04	0.3765E+05
Total Solvents	0.2118E+04	0.1773E+05	0.1227E+04	0.1254E+06	0.3378E+05	0.1980E+05	0.1896E+05	0.1017E+05	0.1679E+06
60 Kent, Delaware	0.1330E+03	0.1048E+01	0.0	0.1312E+03	0.0	0.3861E+01	0.0	0.1795E+02	0.0
Special Naphthas	0.0	0.7720E+02	0.0	0.3643E+03	0.0	0.2332E+03	0.5890E+02	0.0	0.1049E+04
	0.2151E+03	0.1695E+01	0.0	0.2122E+03	0.0	0.6243E+01	0.0	0.2902E+02	0.0
Total Solvents	0.0	0.1248E+03	0.0	0.5891E+03	0.9762E+01	0.4276E+03	0.7522E+02	0.0	0.1574E+04
180 Newcastle, Delaware	0.5919E+03	0.4748E+01	0.1840E+03	0.0	0.1430E+03	0.6217E+02	0.1379E+03	0.0	0.0
Special Naphthas	0.1079E+02	0.2820E+03	0.0	0.1417E+04	0.0	0.6462E+03	0.5414E+03	0.0	0.4289E+04
	0.9572E+03	0.7678E+01	0.2975E+03	0.0	0.2312E+03	0.1005E+03	0.2231E+03	0.0	0.0
Total Solvents	0.1745E+02	0.4560E+03	0.0	0.2291E+04	0.3465E+03	0.1185E+04	0.6914E+03	0.1891E+03	0.6433E+04
240 Sussex, Delaware	0.1270E+03	0.7400E+00	0.0	0.0	0.0	0.2287E+02	0.0	0.0	0.0
Special Naphthas	0.0	0.1125E+03	0.0	0.2631E+03	0.0	0.0	0.4398E+02	0.0	0.1241E+04
	0.2053E+03	0.1197E+01	0.0	0.0	0.0	0.3698E+02	0.0	0.0	0.0
Total Solvents	0.0	0.1819E+03	0.0	0.4524E+03	0.8561E+02	0.0	0.5617E+02	0.0	0.1861E+04
20 District of Columbia	0.1086E+04	0.0	0.0	0.4322E+02	0.6237E+02	0.1280E+02	0.7999E+02	0.2459E+02	0.0
Special Naphthas	0.2242E+01	0.2768E+03	0.0	0.1588E+04	0.0	0.3256E+04	0.1119E+05	0.0	0.6384E+04
	0.1756E+04	0.0	0.0	0.6988E+02	0.1009E+03	0.2070E+02	0.1293E+03	0.3976E+02	0.0
Total Solvents	0.3626E+01	0.4475E+03	0.0	0.2568E+04	0.1206E+03	0.6467E+04	0.1429E+05	0.0	0.9577E+04
140 Honolulu, Hawaii	0.1004E+04	0.4748E+01	0.0	0.2484E+03	0.5360E+02	0.2122E+02	0.8200E+02	0.5115E+02	0.4727E+02
Special Naphthas	0.0	0.1836E+03	0.3015E+02	0.1726E+04	0.0	0.9601E+03	0.6823E+03	0.0	0.5455E+04
	0.1623E+04	0.7678E+01	0.0	0.4017E+03	0.8667E+02	0.3431E+02	0.1326E+03	0.8271E+02	0.7643E+02
Total Solvents	0.0	0.2969E+03	0.4875E+02	0.2791E+04	0.1998E+03	0.1761E+04	0.8714E+03	0.4809E+02	0.8182E+04

TABLE 4-10 (continued)

SOLVENTS BY USER CATEGORY

	Trade Paint SIC 36	Total Man. SIC 7535	Marine SIC 371	Surface Coating SIC 25	Degreasing SIC 34	Dry Cleaning SIC 35 & 36	Printing SIC 26	Rubber SIC 243&244	Transportation Other Users
2580 Ness, Kansas									
Special Naphthas	0.7399E+01	0.3762E+01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.2343E+00	0.0	0.1140E+02	0.0	0.0	0.0	0.0	0.3330E+02
Total Solvents	0.1196E+02	0.6083E+01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.3789E+00	0.0	0.1843E+02	0.0	0.0	0.0	0.0	0.4996E+02
1291 Metropolitan Boston, Massachusetts									
Special Naphthas	0.4101E+04	0.1190E+02	0.2851E+03	0.1098E+04	0.1322E+04	0.2463E+04	0.1184E+04	0.1509E+03	0.0
	0.6370E+03	0.3394E+04	0.2137E+03	0.1486E+05	0.0	0.5367E+04	0.7825E+04	0.0	0.3859E+05
Total Solvents	0.6631E+04	0.1924E+02	0.4610E+03	0.1775E+04	0.2138E+04	0.3982E+04	0.1914E+04	0.2441E+03	0.0
	0.0	0.5487E+04	0.3456E+03	0.2403E+05	0.9799E+04	0.9844E+04	0.9993E+04	0.3840E+04	0.5789E+05
140 Coos, New Hampshire									
Special Naphthas	0.5032E+02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.1717E+02	0.0	0.6749E+02	0.0	0.0	0.2495E+02	0.0	0.3226E+03
Total Solvents	0.8136E+02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.2777E+02	0.0	0.1091E+03	0.0	0.0	0.3186E+02	0.0	0.4839E+03
7960 Schuylkill, Pennsylvania									
Special Naphthas	0.2396E+03	0.0	0.4438E+02	0.6346E+02	0.6508E+02	0.1581E+02	0.4837E+02	0.0	0.3179E+03
	0.2273E+01	0.3006E+03	0.0	0.1098E+04	0.0	0.4115E+02	0.1499E+03	0.0	0.2886E+04
Total Solvents	0.3874E+03	0.0	0.7176E+02	0.1206E+03	0.1052E+03	0.2556E+02	0.7821E+02	0.0	0.5141E+03
	0.3876E+01	0.4861E+03	0.0	0.1775E+04	0.2947E+03	0.7546E+02	0.1915E+03	0.3659E+03	0.4330E+04
2760 Jefferson, Texas									
Special Naphthas	0.3577E+03	0.1005E+03	0.0	0.5723E+02	0.1553E+03	0.2323E+02	0.0	0.0	0.1659E+02
	0.0	0.1547E+03	0.7770E+03	0.1642E+04	0.0	0.6507E+03	0.1625E+03	0.0	0.2494E+04
Total Solvents	0.5784E+03	0.1625E+03	0.0	0.9254E+02	0.2511E+03	0.3756E+02	0.0	0.0	0.2682E+02
	0.0	0.2501E+03	0.1256E+04	0.2655E+04	0.5594E+03	0.1193E+04	0.2076E+03	0.0	0.3742E+04

TABLE 4-11

FUEL USE AND ACTIVITY SUMMARY 1973

DELAWARE

	Coal (Tons) Bituminous	Coal (Tons) Anthracite	Total	LPG (Kilogal.)	Gas (Ft.^{3} x 10^6) Natural	Gas (Ft.^{3} x 10^6) Total Gas Equivalent	Gasoline (Kilogal.)	Diesel (Kilogal.)	Other
Fuel Combustion - External									
Residential	0.902E+03	0.812E+04	0.902E+04	0.116E+05	0.751E+04	0.858E+04			
Commercial/Institutional	0.255E+03	0.308E+04	0.334E+04	0.594E+04	0.315E+04	0.370E+04			
Industrial	0.714E+04	0.0	0.714E+04	0.0	0.307E+04	0.307E+04			
Total Fuel Combustion	0.829E+04	0.112E+05	0.195E+05	0.175E+05	0.137E+05	0.153E+05			
State Sulfur and Ash	Retail		Industrial						
Sulfur %	0.969E+00		0.170E+01						
Ash %	0.798E+01		0.107E+02						
Transportation									
Off-Highway							0.680E+05	0.271E+05	
Railroads								0.126E+04	
Vessels							0.420E+04		
Transportation Sub-Total							0.722E+05	0.284E+05	
Aircraft (LTO Cycles)									
Commercial									0.753E+04
Civil									0.114E+06
Military									0.473E+05
Total Aircraft									0.169E+06
Evaporation Losses									
Retail Gas SaTes (Kilogal.) and Solvents (Tons)									
Retail Gasoline									0.310E+06
Solvents									0.195E+05

V. RECOMMENDATIONS

A number of recommendations for improving the reliability of the fuel allocations are presented in the following sections.

A. IMPROVEMENT OF DATA BASE

1. Point Source Employment

Employment at point sources is a critical element of the industrial allocation methodology. It is recommended that point source employment be routinely collected. If this information is compiled from Dunn and Bradstreet reports, the accuracy of this source should be determined, and its impact of the accuracy of the industrial allocation methodology assessed.

2. Coastline Area Factor

Total boat registrations are allocated among counties according to area, computed as the sum of inland water area and the product of coastline and a coastline area factor. It was not possible within the scope of this study to estimate the required factor. It is recommended that the value of this factor be determined or that an alternate method of estimating county boat populations be developed.

3. Census of Manufactures, Fuel, and Electric Energy Consumed

The Census of Manufactures has previously published a special report on fuel consumed by industry, showing fuel use by type of fuel bv state and two-digit SIC code. It may become an annual publication, in which case it is likely to be an important source of data. The EPA should indicate its interest in seeing this information produced annually.

4. Sulfur and Ash Content Data

The Bureau of Mines annually publishes sulfur content data by production districts. Ash content data, however, are not accurately available by production district. It is recommended that EPA inquire of the Bureau of Mines about the feasibility of reporting ash data by production district.

B. IMPROVEMENT OF METHODOLOGY

1. Fuel Use for Five Commercial Subcategories

Regression analysis was used to develop predictive equations for fuel consumption as a function of the establishment size and climatology for each of the commercial subcategories:

- Hospitals
- Hotels
- Laundries
- Schools
- Universities

The data used to develop these relationships were primarily point sources; therefore, it was implicitly assumed that fuel consumption patterns of what are generally the largest establishments are indicative of the much larger proportion of smaller establishments in each subcategory that are area sources. It is strongly recommended that this assumption be closely examined.

2. Fuel Use for Other Commercial Categories

Predictive equations should be extended to the entire commercial sector in a separate study which could result in fuel consumption figures by two-digit SIC for the commercial subcategories in each state.

3. Solvent Use Patterns

This study estimated for each of seventeen solvents consumption patterns among six application categories:

- Surface Coatings
- Degreasing
- Dry Cleaning
- Printing and Publishing
- Rubber and Plastics
- Other Solvent Use

It is recommended that these consumption patterns be periodically reviewed for two purposes:

- The reclassification from "other solvent use" to one of the five specific categories
- The reexamination of all the consumption patterns to account for petrochemical shortages and technological change within the industry.

4. Sulfur and Ash Content of Bituminous Coal

The methodology for estimating sulfur and ash content of bituminous coal resulted in unrealistically large values for states in which retail consumption is minor and a large portion of industrial consumption is by point sources. This is attributed to inaccuracies in sulfur and ash data reported in the NEDS point source file. It is recommended that an upper limit of sulfur and ash content be set to the highest sulfur and ash content of coal shipped to the state.

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APPENDIX A

REGRESSION ANALYSIS OF RESIDENTIAL GAS CONSUMPTION PATTERNS

Regression analysis was used to construct a predictive equation for county residential natural gas consumption based on climatological and housing stock variables. The regressions were performed on a community-by-community basis for two reasons: (1) The majority of gas companies do not individually service enough counties to provide a significant sample for a regression analysis; (2) it is quite common for a utility to service only a portion of a given county, in which case that utility's sales in the county could not reflect total consumption. Two sets of regressions were executed:

> Regressions using company gas data published in Brown's Directory of North American Gas Companies [48], and
>
> Regressions using community gas data provided to Walden by a number of gas companies across the country

A. REGRESSIONS BASED ON BROWN'S DIRECTORY

A sample of 116 gas companies was extracted from Brown's Directory of North American Gas Companies. One to four companies that had service areas roughly compatable with the political units reported in the U.S. Census of Population and Housing were selected from most states in Brown's Directory. This led to an unavoidable bias to rural areas and small towns, as large gas companies serving one or more metropolitan regions were systematically excluded because socioeconomic and demographic variables could not easily be calculated for their customers.

Regression analysis of average residential gas consumption with degree days and average rooms per housing units yielded poor results. Over the entire sample, this regression had an R^2 of 0.184. Following this, the sample was reduced to 65 companies for which consumption by residential space-heating customers could be separated. A similar regression on this smaller sample with a dependent variable of average residential gas consumption by space-heating customers yielded an R^2 of 0.059. These results compare unfavorably with the regression analyses using the same variables performed previously ($R^2 = 0.674$) [75].

Several explanations for the results from the Brown's Directory sample were investigated. It was thought that the gas utilities' practice of reporting a multi-family structure as a single customer might have been a factor. However, the correlation coefficient between the residuals from the regression and the percentage of the housing units in single-family structures was -0.022, which tends to indicate that it is not as important as was thought.

Second, the 65 companies in our sample for which Brown's Directory gives separate data for house-heating customers are concentrated in the North Central and Northeastern regions of the country. This limited distribution narrows the range of degree days observed in the sample. (The mean of degree days increases from 4,662 in the entire sample to 5,907 in the house-heating sample as the standard deviation drops from 2.373 in the entire sample to 1,797.)

Finally, we have doubts about the accuracy of the consumption data in Brown's Directory. By comparison with the data obtained directly from the gas utilities, differences of as much as an order of magnitude have been observed in residential consumption.

B. REGRESSIONS BASED ON GAS COMPANY DATA

Walden contacted various gas companies across the country to obtain community residential gas sales figures. The gas distribution companies listed below provided data.

Company	Year of Data	States Served
San Diego Gas and Electric	1965-1973	California
Public Service Company of Colorado	1970, 1971, 1972, 1973	Colorado
Pacific Gas and Electric	1973	California
Rochester Gas and Electric	1972, 1973	New York
Baltimore Gas and Electric	1972, 1973	Maryland
Boston Gas	1971, 1972, 1973	Massachusetts
East Ohio Gas Company	1972, 1973	Ohio
Peoples Gas Company	1973	Nebraska, Iowa, Minnesota, Kansas
Southern Union Gas Company	1970, 1971	Arizona, Texas, New Mexico, Colorado

The listed gas companies provided Walden with the total natural gas consumption and number of customers in approximately one thousand communities. This was reduced to a sample of 278 cities, towns, and counties which contained a weather reporting station. A scatter diagram of degree days and therms per housing unit is shown in Figure A-1. Each occurrence of a letter represents a single observation (there is no distinction between letters), while a number indicates more than one observation at that point.

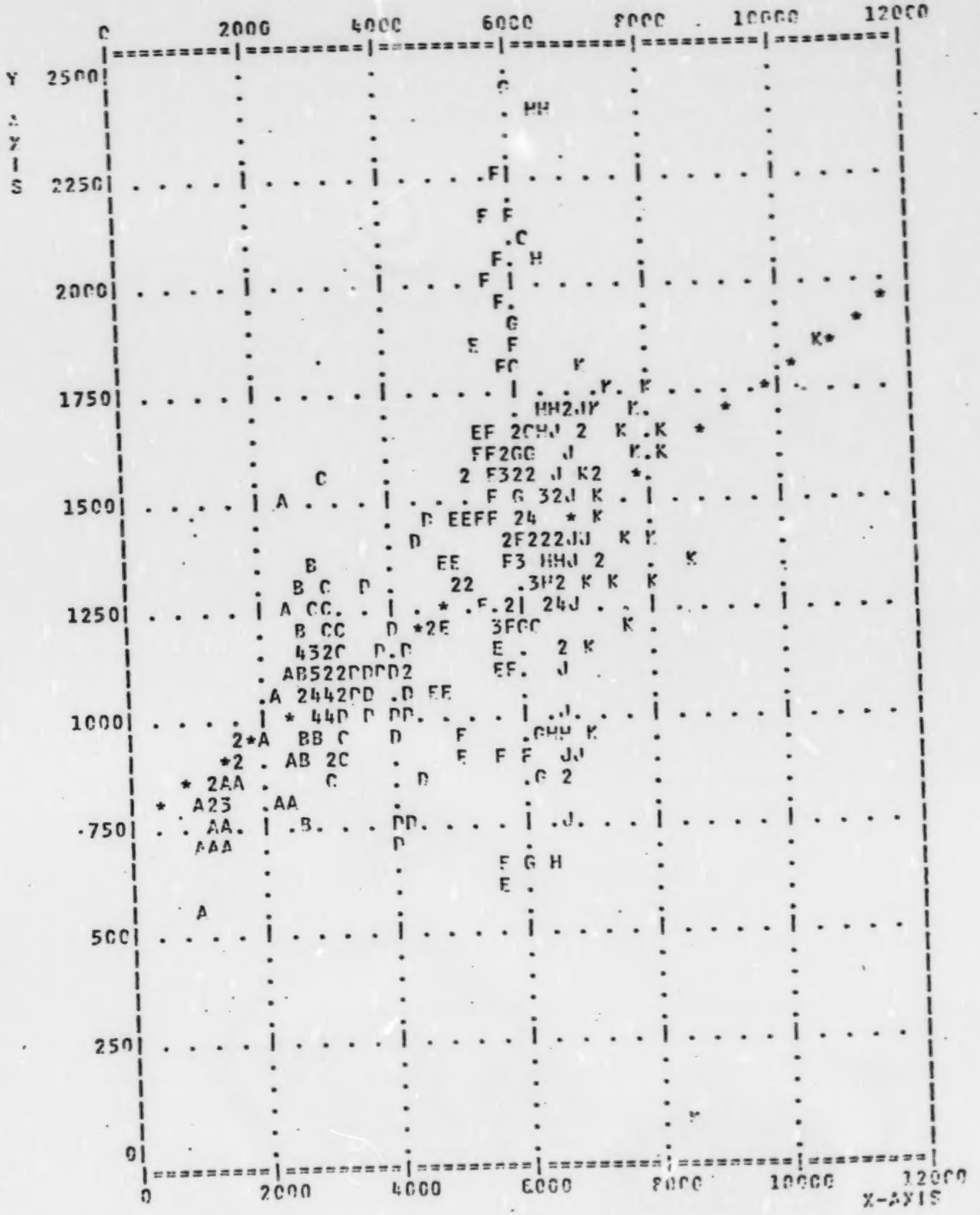
The independent variables considered for inclusion in the regression equation and the sources of data for these variables are as tabulated below:

Item	Description of Variable	Source of Data
A	Degree days, heating season	Climatological Data, NOAA (July issue)
B	Average wind speed, January	Climatological Data, NOAA (January issue)
C	Dwelling units with gas heat	1970 Census of Housing, Bureau of Census
D	Dwelling units with gas hot water	1970 Census of Housing, Bureau of Census
E	Dwelling units with gas range	1970 Census of Housing, Bureau of Census
F	Percent of dwelling units in structures built 1960 or later	1970 Census of Housing, Bureau of Census
G	Rooms per dwelling unit	1970 Census of Housing, Bureau of Census
H	Percent of dwelling units in single-unit structures	1970 Census of Housing, Bureau of Census
I	Percent annual growth of gas-heated dwelling units in state	1972 Gas House-Heating Survey, American Gas Association
J	Latitude	Climatological Data, NOAA
K	Elevation	Climatological Data, NOAA

The first problem encountered was the unavailability of certain housing-stock-related variables (C, D, and E in the above table) for cities with a population less than 10,000. Accordingly, the possibility of a structural shift in gas consumption patterns between cities above and below 10,000 population was investigated. Regressions were performed on the entire sample and two classes (above and below 10,000 population). An F-test was performed contrasting the reduction in the residual sum of squares from the restricted to the unrestricted

FIGURE A-1

SCATTER DIAGRAM OF DEGREE DAYS (X-AXIS) AND
THERMS PER CUSTOMER (Y-AXIS)



regressions. The null-hypothesis of non-homogeneity between the two classes was rejected at confidence level greater than 99%. We will, therefore, assume that the sample of cities with populations greater than 10,000 is representative of the excluded smaller cities.

A similar analysis was performed to test for a shift in gas consumption patterns in 1973 from prior years. The results, however, were inconclusive, since the geographical distribution of the 1973 data is dissimilar from the earlier data. Additional data from gas companies are required to make this analysis feasible.

Two different dependent variables were considered, (1) gas consumption per dwelling unit using gas, and (2) gas consumption per dwelling units using gas for space heating. After preliminary analysis, we elected to use the former. Its use allowed a better fit to the data and involved a less cumbersome methodology. The use of the latter would have necessitated the estimation of gas consumption by gas customers that do not use gas for space heating.

Two models of gas consumption were investigated, namely, an additive linear model of the form:

$$\text{Therms/dwelling unit} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \cdots$$

and a log-log transformation of the linear model:

$$\text{Therms/dwelling unit} = \beta_0 \cdot X_1^{\beta_1} \cdot X_2^{\beta_2} \cdot X_3^{\beta_3} \cdots .$$

The first model assumes no interaction between independent variables and a linear relationship between an independent variable and therms/dwelling unit. There are indications that neither is the case. For example, the impact of the size of the dwelling unit on gas consumption would not be expected to remain constant with a change in degree days. Also, wind speed has a greater impact on construction with a low heat transmission coefficient than on construction with a high heat transmission coefficient. If high heat transmission coefficient construction is primarily in lower degree-day climates, and vice versa, the impact of wind velocity should be greater there.

Regressions in these two forms on an identical set of independent variables yielded, with t-statistics in parentheses, followed by the R^2, corrected

R^2, and F-statistic,

$$\text{Therms/dwelling unit} = -473 + 0.103D + 0.468F + 3.05W + 836\left(\frac{U_{gh}}{U_x}\right)$$

$$(-3.39)\ (12.01)\ (5.14)\ (3.91)\ (8.85)$$

$$R^2 = 0.580 \quad CR^2 = 0.573 \quad F(4,220) = 75.997$$

$$\log(\text{therms/dwelling unit}) = 2.68 + 0.336 \log(D) + 0.088 \log(F) + 0.225 \log(W) + 0.631 \log\left(\frac{U_{gh}}{U_x}\right)$$

$$(9.51)\ (15.16)\ (4.36)\ (4.74)\ (11.46)$$

$$R^2 = 0.677 \quad CR^2 = 0.671 \quad F(4,220) = 100$$

where D = Degree days

F = Percent of dwelling units in structures built after 1960

W = Wind velocity

U_{gh} = Dwelling units using gas for space heating

U_x = The larger of the number of dwelling units using gas for hot water or dwelling units using gas for cooking

The ratio (U_{gh}/U_x) is used as an index to explain the variation in therms/dwelling unit between observations with similar climates, but different percentages of gas customers in a community using gas for space heating. On the basis of the higher R^2 for the log-log transformation, Walden has elected to use it as a basis of the residential gas allocation methodology.

Further analysis showed that log (rooms/dwelling unit) and log (percent dwelling units built after 1960) were multicollinear. Considered separately, they contributed approximately the same to a reduction in the unexplained variation. We have elected to use log (rooms/dwelling unit) for the selected methodology. In addition, wind velocity was omitted from the methodology, as it offered only a small marginal improvement in the regression and was available only at approximately 300 stations in the nation. This made the process of estimating the average wind velocity of a county one of tenuous accuracy. Accordingly, the regression analysis yielded:

$$\log(T) = 3.57 + 0.367 \log(U_g) + 0.588 \log\left(\frac{U_{gh}}{U_x}\right) + 0.125 \log(F)$$

$$(12.60) \qquad (16.35) \qquad (12.02) \qquad (1.97)$$

$$R^2 = 0.631 \qquad CR^2 = 0.626 \qquad F93/221) = 100 \qquad \text{Std. Error} = 0.1653$$

where U_g = Number of occupied dwelling units using gas

D = Annual degree days

U_{gh} = Number of occupied dwelling units using gas for space heating

U_x = The larger of the number of occupied dwelling units using gas for cooking or for hot water

F = Median rooms per dwelling units, in tenths

which reduces to

$$\text{Therms} = 47.5 * U_g * D^{0.36} * \left(\frac{U_{gh}}{U_x}\right)^{0.588} * F^{0.125}$$

APPENDIX B

REGRESSION ANALYSIS OF COMMERCIAL FUEL CONSUMPTION FOR FIVE SUBCATEGORIES

The basic methodology to determine commercial fuel consumption on a county basis is to estimate fuel consumption in five separate categories and to distribute the remainder within the state by commercial employment. The subcategories are used for two reasons:

- Employment in three of the categories (schools, universities, and hospitals) is not fully reported in County Business Patterns, and
- Fuel consumption in the five categories was assumed to be relatively homogenous and distinct from other commercial fuel consumption. Given this assumption, the county allocation can be made more accurately if these five categories are treated separately.

It was, therefore, decided to analyze the relationship between fuel use and employment for several subcategories in order to determine the fuel use for these categories in a direct way, based on the number of employees in each subcategory. We also anticipated that a positive relationship might exist between the quantity of fuel consumed and degree days [3]. Regression analysis was, therefore, performed in the following two forms for each of the subcategories:

$$\text{Therms} = a + B\ (\text{employment})$$
$$\text{Therms} = a + B_1\ (\text{employment}) + B_2\ (\text{degree days})$$

Analysis was also done using a log-log transformation

$$\text{Therms} = a\ (\text{employment})^{B1}\ (\text{degree days})^{B2}$$

However, this latter model generally produced smaller R^2s than the two linear forms.

Fuel use consumption data of individual companies and institutions for the subcategories was extracted from the NEDS point source file, converted to therms, and analyzed with employment and degree day data. The results of each of these analyses are discussed below.

A. UNIVERSITIES

Fuel use data for 102 universities were extracted from the NEDS point source file. Employment data were obtained from an HEW survey of employees in institutions of higher learning [50]. Regression analysis yielded (with t-statistics in parentheses):

$$\text{Kilotherms} = 24{,}170 + \underset{(16.9)}{224}\ \text{employees}$$

$$R^2 = 0.742 \qquad \text{Standard error} = 371{,}561$$

$$\text{Kilotherms} = -294{,}100 + \underset{(17.83)}{229}\ \text{employees} + \underset{(2.93)}{51.5}\ \text{degree days}$$

$$R^2 = 0.763 \qquad \text{Standard error} = 358{,}191$$

The second equation for university fuel use by county is a better fit to the data sample. This equation will, however, estimate a negative therm use in a small number of counties with low degree days and low university employment. For example, a county with 1,000 degree days would need 1,060 university employees in order to have positive therm consumption. In such cases, fuel consumption by universities will be assumed to equal zero.

Enrollment by institution is available annually from the U.S. Office of Education in both printed and machine-readable format [50]. Enrollment in in public institutions is summarized by county; this can be converted to employment by a public employee/enrollment ratio derived below. The result, public institution employment reported in County Business Patterns [13], can be used as the employment input variable for the regression equation.

The derivation of a public institution employee/enrollment ratio is based on the most recent higher education employment data released by the U.S. Office of Education [50]. Comparing the enrollment and employment data for 1967, the public employee/enrollment ratio was 0.178. This ratio is used to estimate public institution employment from enrollment.

B. SCHOOLS

Fuel consumption data were available for 85 elementary and secondary schools from the NEDS point source file. Employment data for instructors by school were listed in an HEW publication [51]; total school employment figures were then calculated from a state ratio derived from a second HEW survey that listed secretarial, plant, and food service personnel [52]. The regression analysis yielded

$$\text{Kilotherms} = 1{,}090 + \underset{(9.4)}{172}\ \text{employees}$$

$$R^2 = 0.517 \qquad \text{Standard error} = 13{,}011$$

$$\text{Kilotherms} = -18{,}200 + \underset{(8.98)}{165}\ \text{employees} + \underset{(2.05)}{4.10}\ \text{degree days}$$

$$R^2 = 0.540 \qquad \text{Standard error} = 12{,}766$$

The second equation provides a higher R^2 and uses two independent variables to explain fuel consumption in schools. The negative intercept is not large enough to be a problem in the school equation, as was the case in the university equation.

County employment in private schools is available annually from County Business Patterns [13]. Public school employment can be estimated from the annual state public school employment [53], apportioned to counties by the population of 3-34-year-old persons enrolled in regular public elementary and secondary schools, as reported in Census of Population, 1970 [5]. The sum of the private and public employment is used as the employment input variable for the elementary and secondary school fuel equation.

C. LAUNDRIES

Fuel data for 16 laundries was extracted from the NEDS point source file and correlated with employment figures from the Dun and Bradstreet file and supplemented by a telephone survey. Regression analysis using only employment data yielded

$$\text{Kilotherms} = -12{,}800 + \underset{(3.4)}{531}\ \text{employees}$$

$$R^2 = 0.771 \qquad \text{Standard error} = 28{,}298$$

The coefficient of degree days was insignificant in the multivariate form.

D. HOSPITALS

The fuel use of 99 hospitals was extracted from the NEDS point source file. Employment data were obtained from the American Hospital Association Guide to the Health Care Field [11]. Regression analysis yielded

$$\text{Kilotherms} = 30{,}100 + \underset{(5.88)}{126}\ \text{employees}$$

$$R^2 = 0.263 \qquad \text{Standard error} = 128{,}758$$

$$\text{Kilotherms} = -45{,}200 + \underset{(5.78)}{120}\ \text{employees} + \underset{(2.87)}{15.0}\ \text{degree days}$$

$$R^2 = 0.322 \qquad \text{Standard error} = 124{,}201$$

While the coefficients have the expected signs and significant t-statistics, The R^2s are disappointing. Further analysis showed somewhat better results by performing separate regressions of the same form for each Census Region.

The regional analysis still produced poor results. In an attempt to improve the results, fuel consumption was regressed on hospital bed data obtained from the American Hospital Association [11] and degree days:

$$\text{Kilotherms} = -20{,}400 + \underset{(6.30)}{176}\ \text{beds} + \underset{(2.59)}{13.3}\ \text{degree days}$$

$$R^2 = 0.353 \qquad F\ (2{,}96) = 26.17 \qquad \text{Standard error} = 121{,}307$$

When the two regressions were run on the four geographical regions (northeast, South, Central, and Pacific), it was found that employment and beds produced substantially different results from one region to another. For example, employment in the Northeast was a far better indicator of fuel consumption than beds (R^2 = 0.771 for employment, compared to R^2 = 0.399 for beds). Conversely, in the South, beds were a better indicator for fuel consumption than employment (R^2 = 0.780 for beds, compared to R^2 = 0.363 for employment). For this reason, it was decided to run a regression using all three independent variables: beds, degree days, and employment. Multicollinearity between beds and employment is not a significant problem; the simple correlation between them is 0.51. This regression analysis yielded

$$\text{Kilotherms} = -57{,}200 + \underset{(4.2)}{126.5}\ \text{beds} + \underset{(2.6)}{12.7}\ \text{degree days} + \underset{(3.5)}{77.4}\ \text{employment}$$

$R^2 = 0.430$ $F(3,95) = 23.84$ Standard error = 114,493

Some improvement in the R^2 and standard error statistics was observed. Examination of the results suggested that the fuel consumption data from the Central region were primarily responsible for the poor overall performance.

This last regression equation can be used to estimate county hospital fuel consumption as a function of beds, employment, and degree days. The scope of the study did not warrant further analysis beyond the effort reported above.

Employment data from the County Business Patterns were found to be incomplete, as the CBP does not include employment for government hospitals. The American Hospital Association compiles employment and beds data on an annual basis. These data are available in machine-readable format; however, their cost was prohibitive for use in the data processing phase of this study.

E. HOTELS

Fuel consumption data by hotels were obtained from the NEDS point source file and through contact with the Hilton Hotel Corporation. While employment data for each hotel proved to be unobtainable, rooms in each hotel were available from the Hotel and Motel Red Book [12]. Regression analysis for therms on degree days and rooms yielded (with t-statistics in parentheses)

$$\text{Therms} \times 10^{-4} = -39{,}100 + \underset{(7.35)}{25.54}\ \text{rooms} + \underset{(2.15)}{5.514}\ \text{degree days}$$

$R^2 = 0.797$ $CR^2 = 0.773$ $F(2,17) = 33.3$ Standard error = 12,087

In this case, the critical t-statistics for testing a null hypothesis of a coefficient equaling zero is 1.740 in a one-tailed test.

Of the 20 hotels included in the sample, four hotels had rooms in excess of 2,000. Inspection of the data showed that these hotels were using much more fuel than would be expected from the rest of the sample. With the four hotels deleted from the sample, all three coefficients decreased by an order of magnitude:

$$\text{Therms} \times 10^{-4} = -3{,}000 + 2.95 \text{ rooms} + 0.437 \text{ degree days}$$

(4.32) (1.68)

$R^2 = 0.590$ $CR^2 = 0.527$ $F(2,13) = 9.34$ Standard error = 1,069

The change between the two regressions and inspection of the data tend to indicate an appreciable change in fuel consumption per room between hotels of different sizes; the larger hotels in the sample are using much more fuel per room than the smaller ones. Therefore, a non-linear regression was run that allowed a curve with a positive and increasing slope to be fitted to the sample. Using a log-log transformation,

$$\log (\text{therms} \times 10^{-4}) = -46.3 + 2.84 \log (\text{rooms}) + 3.99 \log (\text{degree days})$$

(16.31) (4.11)

$R^2 = 0.944$ $CR^2 = 0.937$ $F(2,17) = 143.14$ Standard error = 0.882

F 95% = 3.59

In the exponential form, this equation becomes

$$\text{Therms} \times 10^{-4} = (8.049 \times 10^{-21}) \times \text{rooms}^{2.839} \times \text{degree days}^{3.991}$$

which, when used to predict the sample, has a sum of squared residuals of 0.283 x 10^{10}, a standard error of 12,918, and an R^2 of 0.768. The standard error of this regression is slightly higher than the standard error of the linear one on the entire sample, 12,087, while the R^2 is slightly less, 0.766 vs. 0.797.

The data sample and the three equations discussed above are plotted in Figures B-1 and B-2, respectively. The exponential function is used to estimate county hotel consumption of fuel as a function of rooms and degree days:

$$T_R = T_{R_0} + \left.\frac{\delta T}{\delta R}\right|_{R = R_0} * (R - R_0)$$

where T_R = Energy consumption at data point R

T_{R_0} = Energy consumption at reference point R_0

$\frac{\delta T}{\delta R}$ = Slope of this function

R = Total rooms in county

R_0 = Average number of rooms per hotel for the county

An R_0 for the entire country is used; variation in this parameter on an individual county basis will not be considered.

The number of hotel rooms is not reported on a county basis; instead, it must be estimated from the county employment [13] and room-employee ratios derived from the Census of Business (shown in Table B-1) [54].

FIGURE B-1. Plot of Hotel Rooms vs. Fuel Use

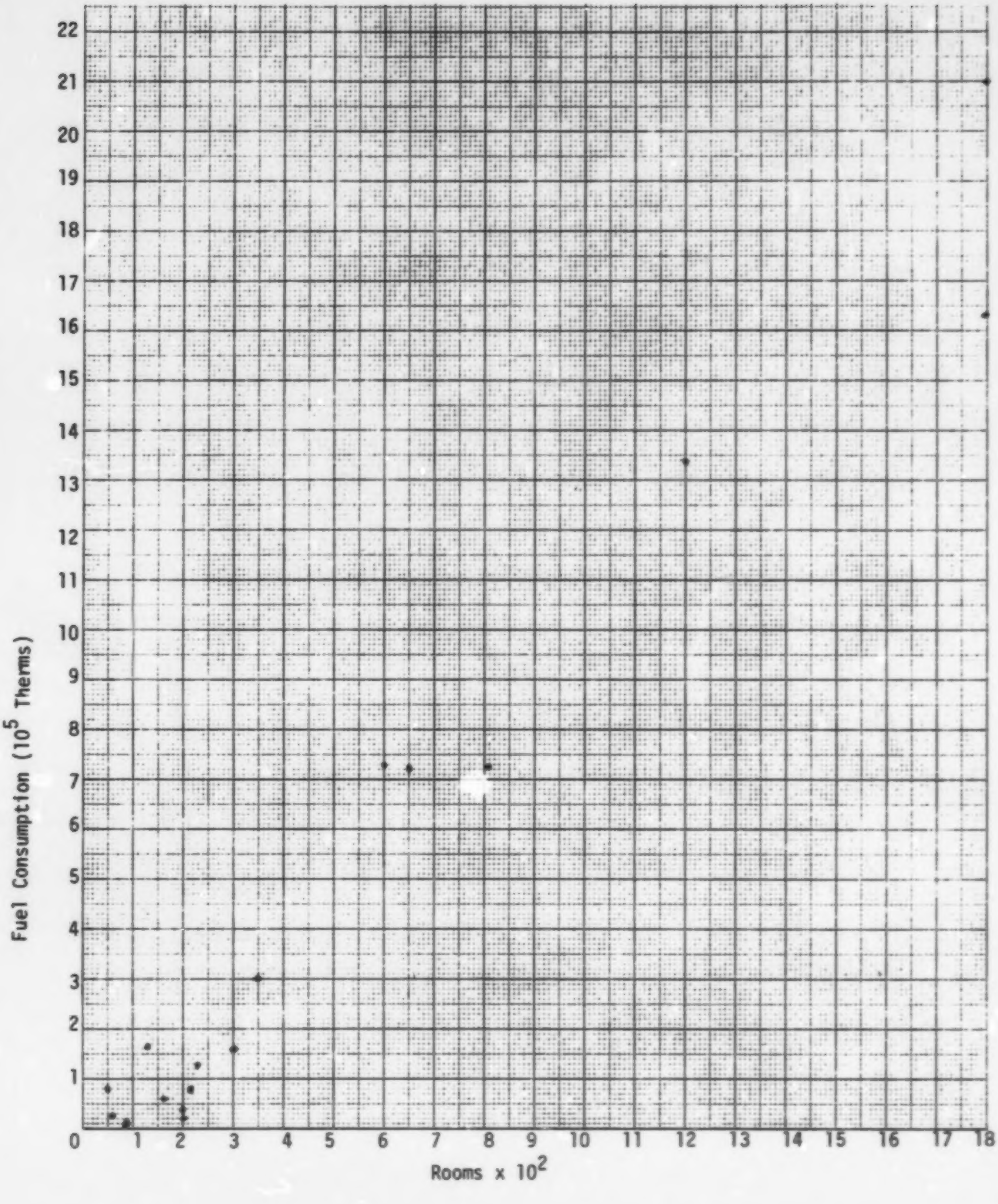


FIGURE B-2. Plot of Three Fuel Use Regression Equations

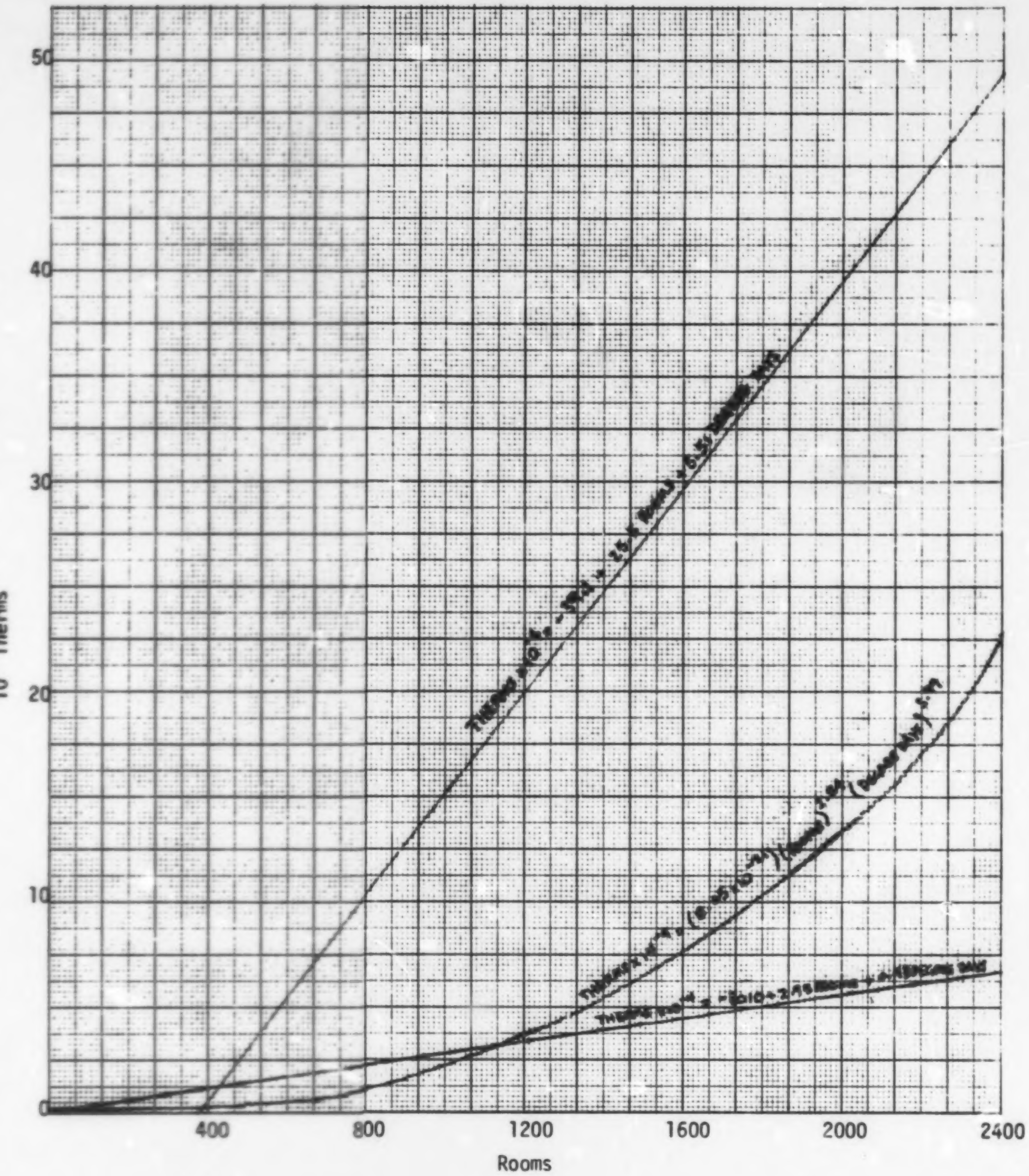


TABLE B-1

EMPLOYEE/ROOM RATIOS FOR HOTELS BY STATE

State	Ratio	State	Ratio	State	Ratio
AL	0.28	MI	0.27	UT	0.22
AK	0.21	MN	0.35	VT	0.26
AZ	0.29	MS	0.28	VI	0.29
AR	0.39	MO	0.30	WA	0.26
CA	0.27	MT	0.20	WV	0.29
CO	0.29	NB	0.26	WI	0.31
CN	0.37	NV	0.80	WY	0.20
DE	0.13	NH	0.23		
DC	0.58	NJ	0.27		
FL	0.34	NM	0.23		
GA	0.33	NY	0.31		
HI	0.56	NC	0.22		
ID	0.21	ND	0.21		
IL	0.32	OH	0.31		
IN	0.30	OK	0.22		
IO	0.28	OR	0.29		
KA	0.23	PA	0.36		
KY	0.30	RI	0.36		
LA	0.38	SC	0.28		
ME	0.16	SD	0.16		
MD	0.29	TN	0.28		
MA	0.34	TX	0.32		

Source: 1967 Census of Business: Selected Services [54]

APPENDIX C

ANALYSIS OF ALTERNATE DATA SOURCES FOR STATE COAL, GAS, AND LPG SHIPMENTS/CONSUMPTION

A large number of publications on coal, natural gas, and LPG use were surveyed and evaluated. This survey aided in determining the basic fuel use sources on which to base the state-by-state figures which form the main structure for the county allocation methods. The various data sources and the methods derived to obtain state totals are discussed below.

A. BITUMINOUS COAL

1. Sources

The sole source of data available on the distribution of bituminous coal by state by consumer class is the Bureau of Mines Mineral Industry Survey: Bituminous Coal and Lignite Distribution [10]. This is identical with the data later published by the Bureau of Mines in the Mineral Yearbook [27] and the Energy Fact Sheets [55], as well as the source for information published by the National Coal Association in Bituminous Coal Facts [56] and Bituminous Coal Data [57].

The 1971 state-by-state distribution of bituminous coal, as reported in the Mineral Industry Surveys, is listed in Table C-1. These shipment statistics are based on a quarterly survey of producers and wholesalers who annually handle in excess of 100,000 tons; the survey covers about 91% of all coal produced. A facsimile of the quarterly coal canvass is shown in Figure C-1.

Despite the detailed shipment data, the Bureau of Mines does not report consumption of bituminous coal within each state by consumer class. This is only done on a national level in the manner shown in Table C-2 [27, 58]. While these consumption figures are not directly relevant to the needs of this project, they will be useful for evaluating the accuracy of using the shipment data as an estimate for consumption after correcting for exports, imports, and net year-end change in stocks.

TABLE C-1

DISTRIBUTION OF BITUMINOUS COAL IN 1971

(Thousands of Net Tons)

Region and State of Destination	Electric Utilities	Coke and Gas Plants	Shipments to Retail Dealers (Residential and Commercial)	All Other (Industrial)	Total
NEW ENGLAND					
Massachusetts	122	—	14	91	227
Connecticut	1,185	—	—	86	1,271
Maine, New Hampshire, Vermont, Rhode Island	877	—	7	63	947
MIDDLE ATLANTIC					
New York	7,373	4,188	54	3,981	15,596
New Jersey	2,862	—	2	110	2,974
Pennsylvania	30,273	21,760	640	6,309	58,982
EAST NORTH CENTRAL					
Ohio	38,579	10,630	1,299	12,608	63,116
Indiana	21,790	11,164	640	5,005	38,599
Illinois	27,930	3,347	1,871	5,141	38,289
Michigan	19,416	4,861	817	7,531	32,625
Wisconsin	10,449	405	1,299	3,187	15,340
WEST NORTH CENTRAL					
Minnesota	6,403	509	500	901	8,313
Iowa	4,815	—	113	1,311	6,239
Missouri	11,655	298	73	1,332	13,358
North & South Dakota	4,718	—	143	411	5,272
Nebraska & Kansas	1,928	—	41	256	2,225
SOUTH ATLANTIC					
Delaware & Maryland	6,408	4,369	41	781	11,599
District of Columbia	283	—	29	286	598
Virginia	5,821	27	407	3,003	9,258
West Virginia	17,458	4,323	239	4,586	26,606
North Carolina	17,687	—	355	1,737	19,779
South Carolina	4,589	—	219	1,411	6,219
Georgia & Florida	15,763	—	77	455	16,295
EAST SOUTH CENTRAL					
Kentucky	21,611	1,660	341	1,978	25,590
Tennessee	16,637	174	549	1,547	18,907
Alabama & Mississippi	17,761	7,310	101	2,522	27,694

TABLE C-1

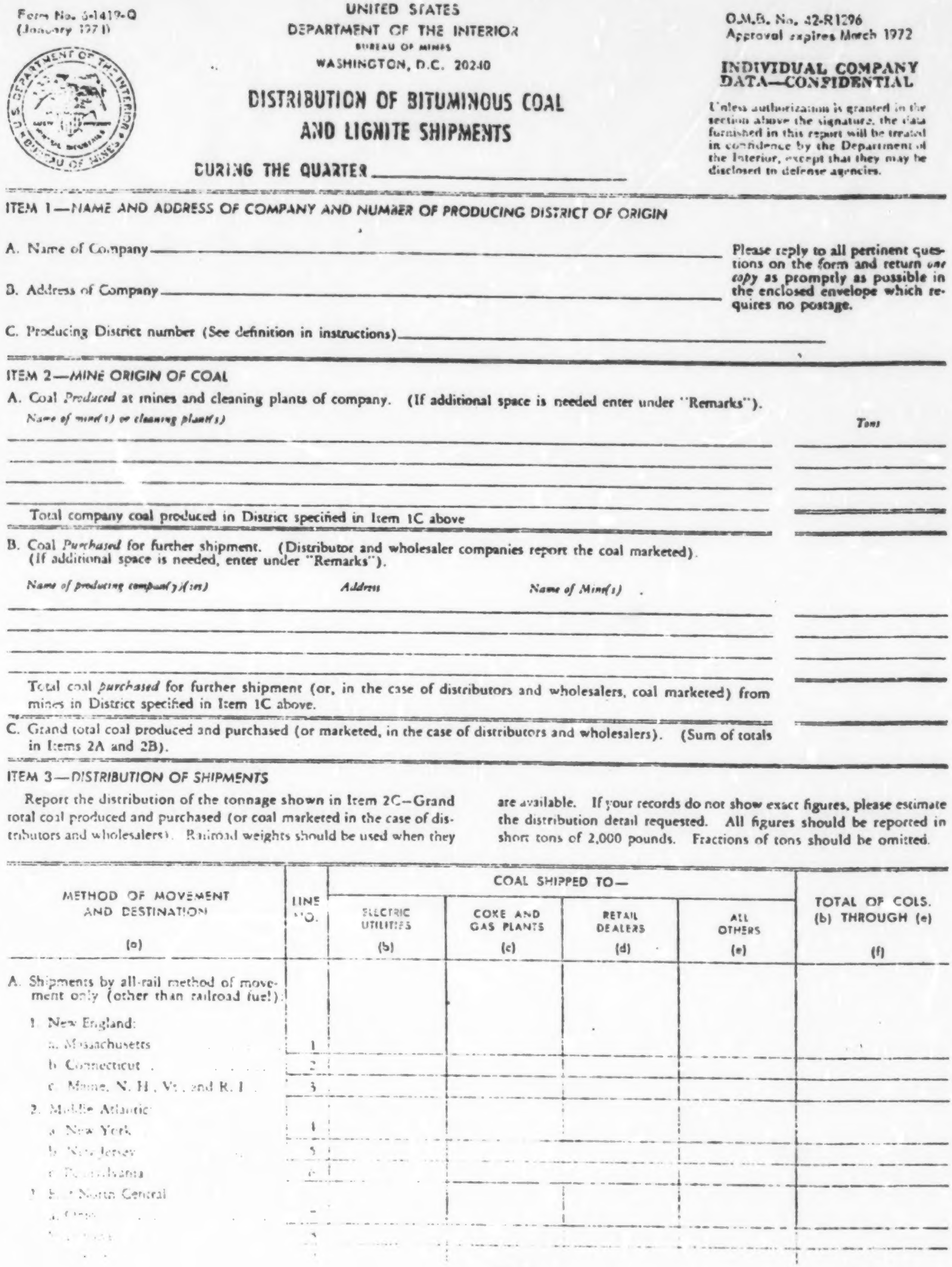
DISTRIBUTION OF BITUMINOUS COAL IN 1971

(Thousands of Net Tons)

Region and State of Destination	Electric Utilities	Coke and Gas Plants	Shipments to Retail Dealers (Residential and Commercial)	All Other (Industrial)	Total
WEST SOUTH CENTRAL					
Arkansas, Louisiana, Oklahoma, Texas	—	840	4	43	887
MOUNTAIN					
Colorado	3,019	901	212	343	4,475
Utah	472	1,787	228	506	2,993
Montana & Idaho	782	—	299	267	1,348
Wyoming	3,542	—	26	160	3,728
New Mexico	6,701	—	1	11	6,713
Arizona & Nevada	2,184	—	27	113	2,324
PACIFIC					
Washington & Oregon	1,083	—	86	313	1,482
California	—	1,830	3	14	1,847
Alaska	261	—	19	468	748
Destinations Not Revealable	580	195	117	278*	1,170
Sub-Total	333,017	80,578	10,893	69,145	493,633
DESTINATIONS AND/OR CONSUMER USERS NOT AVAILABLE					
Great Lakes Movement					
Vessel Fuel					713
U.S. Dock Storage					-263
Railroad Fuel					
United Stated Co.					528
Coal Used at Mines & Sales to Employees					1,483
Net Change in Inventory					397
TOTAL DISTRIBUTION					496,491
TOTAL IMPORTS					111
FINAL TOTAL DISTRIBUTION					496,602
Growth in Consumers' Stocks					-1,643
ESTIMATED U.S. CONSUMPTION					494,959

* Walden estimate based on total export figures published by the Bureau of Mines.

Figure C-1.Questionnaire Used by the Bureau of Mines for Bituminous Coal and Lignite



Form No. 6-1419-Q
(January 1971)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
WASHINGTON, D.C. 20240

O.M.B. No. 42-R1296
Approval expires March 1972

INDIVIDUAL COMPANY DATA—CONFIDENTIAL

Unless authorization is granted in the section above the signature, the data furnished in this report will be treated in confidence by the Department of the Interior, except that they may be disclosed to defense agencies.

DISTRIBUTION OF BITUMINOUS COAL AND LIGNITE SHIPMENTS

DURING THE QUARTER ____________________

ITEM 1—*NAME AND ADDRESS OF COMPANY AND NUMBER OF PRODUCING DISTRICT OF ORIGIN*

A. Name of Company ____________________

B. Address of Company ____________________

C. Producing District number (See definition in instructions) ____________________

Please reply to all pertinent questions on the form and return *one copy* as promptly as possible in the enclosed envelope which requires no postage.

ITEM 2—*MINE ORIGIN OF COAL*

A. Coal *Produced* at mines and cleaning plants of company. (If additional space is needed enter under "Remarks").

Name of mine(s) or cleaning plant(s)	*Tons*
Total company coal produced in District specified in Item 1C above	

B. Coal *Purchased* for further shipment. (Distributor and wholesaler companies report the coal marketed). (If additional space is needed, enter under "Remarks").

Name of producing company(ies)	*Address*	*Name of Mine(s)*	
Total coal *purchased* for further shipment (or, in the case of distributors and wholesalers, coal marketed) from mines in District specified in Item 1C above.			

C. Grand total coal produced and purchased (or marketed, in the case of distributors and wholesalers). (Sum of totals in Items 2A and 2B). ______

ITEM 3—*DISTRIBUTION OF SHIPMENTS*

Report the distribution of the tonnage shown in Item 2C—Grand total coal produced and purchased (or coal marketed in the case of distributors and wholesalers). Railroad weights should be used when they are available. If your records do not show exact figures, please estimate the distribution detail requested. All figures should be reported in short tons of 2,000 pounds. Fractions of tons should be omitted.

METHOD OF MOVEMENT AND DESTINATION (a)	LINE NO.	COAL SHIPPED TO— ELECTRIC UTILITIES (b)	COKE AND GAS PLANTS (c)	RETAIL DEALERS (d)	ALL OTHERS (e)	TOTAL OF COLS. (b) THROUGH (e) (f)
A. Shipments by all-rail method of movement only (other than railroad fuel):						
1. New England:						
a. Massachusetts	1					
b. Connecticut	2					
c. Maine, N. H., Vt., and R. I.	3					
2. Middle Atlantic:						
a. New York	4					
b. New Jersey	5					
c. Pennsylvania	6					
3. East North Central:						
a. Ohio	7					
[illegible]	8					

c. Illinois						
d. Michigan	10					
e. Wisconsin	11					
4. West North Central:						
a. Minnesota	12					
b. Iowa	13					
c. Missouri	14					
d. North Dakota and South Dakota	15					
e. Nebraska and Kansas	16					
5. South Atlantic:						
a. Delaware and Maryland	17					
b. District of Columbia	18					
c. Virginia	19					
d. West Virginia	20					
e. North Carolina	21					
f. South Carolina	22					
g. Georgia and Florida	23					
6. East South Central:						
a. Kentucky	24					
b. Tennessee	25					
c. Alabama and Mississippi	26					
7. West South Central (Ark., La., Okla. and Tex.)	27					
8. Mountain:						
a. Colorado	28					
b. Utah	29					
c. Montana and Idaho	30					
d. Wyoming	31					
e. New Mexico	32					
f. Arizona and Nevada	33					
9. Pacific:						
a. Washington and Oregon	34					
b. California	35					
10. Alaska	36					
11. Canada	37					
12. State and use unknown	38	▨	▨	▨	▨	
13. Total all-rail shipments	39					
B. Shipments via river method of movement only (other than railroad fuel) LIST STATES:						
	1					
	2					
	3					
	4					
	5					
Total shipments via river	6					
C. Shipments via ex-river method of movement only (other than railroad fuel) LIST STATES:						
	1					
	2					
	3					
	4					
	5					
	6					
	7					
Total shipments via ex-river	8					

Please continue form and sign certification on reverse

Figure C-1 (continued)

Reproduced from best available copy.

ITEM 3—*DISTRIBUTION OF SHIPMENTS (Continued)*

METHOD OF MOVEMENT AND DESTINATION (a)	LINE NO.	COAL SHIPPED TO—				TOTALS OF COLS. (b) THROUGH (e) (f)
		ELECTRIC UTILITIES (b)	COKE AND GAS PLANTS (c)	RETAIL DEALERS (d)	ALL OTHERS (e)	
D. Shipments via Great Lakes ports (other than railroad fuel):						
New York	1					
Pennsylvania	2					
Ohio	3					
Indiana	4					
Illinois	5					
Michigan	6					
Wisconsin	7					
Minnesota	8					
State and use unknown	9	▨	▨	▨	▨	
Canada	10					
Shipments to commercial docks:						
United States	11	▨	▨	▨	▨	
Canada	12	▨	▨	▨	▨	
Vessel fuel	13	▨	▨	▨		
Total shipments via Great Lakes	14					
E. Shipments via tidewater ports (other than railroad fuel):						
Massachusetts	1					
Connecticut	2					
Maine and Rhode Island	3					
New York	4					
New Jersey	5					
Pennsylvania	6					
Delaware and Maryland	7					
Virginia	8					
Other States (List) ____	9					
____	10					
____	11					
____	12					
State and use unknown	13	▨	▨	▨	▨	
Canada	14					
Overseas exports (except Canada)	15	▨	▨	▨	▨	
Shipments to commercial docks	16	▨	▨	▨	▨	
Bunker fuel	17	▨	▨	▨		
Total shipments via tidewater	18					
F. Shipments via truck (other than railroad fuel). Destination known—LIST STATES:						
____	1					
____	2					
____	3					
____	4					
State and use unknown	5	▨	▨	▨	▨	
Total shipments via truck	6					
G. Shipments via tramway, conveyor, and private railroad (other than railroad fuel)—LIST STATES:						
____	1					
____	2					
Total shipments via tramway, conveyor, and private railroad	3					
H. Railroad fuel (Engine, powerhouse, and station use, all methods of movement):						
United States companies	1	▨	▨	▨	▨	
Canadian companies	2	▨	▨	▨	▨	

Figure C-1 (continued)

J. Shipments to distributors and wholesalers (destination and use unknown) — Total Tons	1	

1. Provide below names, addresses, and tons shipped to distributors and wholesalers when destinations and uses are unknown to you [illegible] for total tons reported in Item 3J. (If additional space is needed, enter under "Remarks").

Name(s) of distributor(s) and wholesaler(s)	*Address*	*Tons*
Total shipments to distributors and wholesalers, destinations and uses unknown		

RECAPITULATION

ITEM 4—*TOTAL SHIPMENTS (Bring forward totals of Items 3A through 3J)*

Item	*Line*	*Method of movement and use*	*Tons*
3A	39	Total shipments via all-rail method of movement	
3B	6	Total shipments via river method of movement	
3C	8	Total shipments via ex-river method of movement	
3D	14	Total shipments via Great Lakes method of movement	
3E	18	Total shipments via tidewater method of movement	
3F	6	Total shipments via truck method of movement	
3G	3	Total shipments via tramway, conveyor, and private railroad	
3H	3	Total railroad fuel	
3J	1	Total shipments to distributors and wholesalers (destination and use unknown)	
		Total shipments	

ITEM 5— Coal used at mine(s) and sales to employees ____________

ITEM 6— Net change in inventory ____________

ITEM 7— Total coal produced and purchased (same as Item 2C) ____________

REMARKS

Your cooperation is appreciated. If you desire a copy of the published report, please check here ....

CERTIFICATION

Name and address of person who should be contacted if questions arise regarding this report. Telephone No.

BASED UPON THE INFORMATION IN THIS REPORT, MAY THE BUREAU OF MINES PUBLISH DATA WHICH COULD REVEAL YOUR OPERATIONS? YES ☐ NO ☐

SIGNATURE	OFFICIAL POSITION	DATE OF REPORT

INT.-BU.OF MINES,PGH.,PA. 15927

Figure C-1 (continued)

TABLE C-2

United States Consumption and Exports of Bituminous Coal

(Thousands of Net Tons)

	Consumed in the United States								Exports		
			Manufacturing and Mining Industries								
	Electric Power Utilities	Railroads (Class I)	Coking Coal	Steel & Rolling Mills *	Cement Mills	Other Manufacturing & Mining Industries[1] *	Retail Deliveries to Other Consumers +	Total U. S. Consumption	To Canada	To All Other Countries	Total Exports
1933	27,088	72,548	40,089	14,129	2,760	83,675	77,396	317,685	8,607	430	9,037
1938	36,440	73,921	46,626	11,877	4,413	96,506	66,498	336,291	9,577	913	10,490
1939	42,304	79,072	63,514	13,843	5,194	103,401	68,770	376,098	10,043	1,547	11,590
1940	49,126	85,130	81,386	14,169	5,559	110,853	84,687	430,910	13,623	2,843	16,465
1941	59,888	97,384	93,138	15,384	6,735	125,184	94,402	492,115	18,376	2,364	20,740
1942	63,472	115,410	100,850	14,722	7,462	135,993	102,141	540,050	21,099	1,844	22,943
1943	74,036	130,283	102,460	15,864	5,842	145,191	120,121	593,797	24,371	1,465	25,836
1944	76,656	132,049	105,296	15,152	3,767	134,567	122,112	589,599	24,516	1,516	26,032
1945	71,603	125,120	95,349	14,241	4,203	129,754	119,297	559,567	21,767	6,189	27,956
1946	68,743	110,166	83,288	12,151	6,990	120,364	98,684	500,386	22,033	19,164	41,197
1947	86,009	109,296	104,800	14,195	7,919	127,015	96,657	545,891	26,170	42,497	68,667
1948	95,620	94,838	107,306	14,193	8,546	112,612	86,794	519,909	25,998	19,932	45,930
1949	80,610	68,123	91,236	10,529	7,966	98,685	88,389	445,538	16,098	11,744	27,842
1950	88,262	60,969	103,845	10,877	7,923	97,904	84,422	454,202	23,009	2,459	25,468
1951	101,898	54,005	113,448	11,260	8,507	105,408	74,378	468,904	22,823	33,899	56,722
1952	103,309	37,962	97,614	9,632	7,903	95,476	66,861	418,757	20,957	26,686	47,643
1953	112,283	27,735	112,874	8,764	8,167	96,999	59,976	426,798	19,584	14,176	33,760
1954	115,235	17,370	85,391	6,983	7,924	78,359	51,758	363,060	15,910	15,131	31,041
1955	140,550	15,473	107,377	7,353	8,529	91,110	53,020	423,412	17,185	34,092	51,277
1956	154,983	12,308	105,913	7,189	9,026	94,772	48,667	432,858	20,654	47,899	68,553
1957	157,398	8,401	108,020	6,938	8,633	88,566	35,712	413,668	18,445	58,001	76,446
1958	152,928	3,725	76,580	7,268	8,256	82,327	35,619	366,703	12,235	38,055	50,291
1959	165,788	2,600	79,181	6,674	8,510	74,365	29,138	356,256	12,407	24,846	37,253
1960	173,882	2,101	81,015	7,378	8,216	77,432	30,405	380,429	11,639	24,870	36,541
1961	179,629	([2])	73,881	7,495	7,615	78,050	27,735	374,405	11,169	23,801	34,970
1962	190,833	([2])	74,262	7,319	7,719	79,453	28,188	387,774	11,410	27,003	38,413
1963	209,038	([2])	77,633	7,401	8,138	83,467	23,548	409,225	13,762	33,316	47,078
1964	223,032	([2])	88,757	7,394	8,679	83,639	19,615	431,116	14,187	33,782	47,969
1965	242,729	([2])	94,779	7,466	8,873	86,269	19,048	459,164	15,661	34,521	50,181
1966	264,202	([2])	95,892	7,117	9,149	89,941	19,965	485,266	15,829	33,474	49,302
1967	271,784	([2])	92,272	6,330	8,922	84,009	17,099	480,416	15,308	34,220	49,528
1968	294,739	([2])	90,765	5,657	9,391	83,054	15,224	498,830	16,748	33,889	50,637
1969	308,461	([2])	92,901	5,560	([2])	85,687	14,666	507,275	16,788	39,446	56,234
1970	318,921	([2])	96,009	5,410	([2])	83,207	12,072	515,619	18,673	52,270	70,944
1971	326,280	([2])	82,809	5,560	([2])	68,862	11,351	494,862	17,565	39,068	56,632

[1] Includes bunker fuel.

[2] Included in other Manufacturing and Mining Industries.

Source: U.S. Bureau of Mines

* Used in Industrial Category

+ Used in Retail (Commercial and Residential) Category

2. Distribution Versus Consumption

If the net change in year-end stock and exports [27,58] is subtracted from the total U.S. shipments of bituminous coal in 1971 and the imports [27,58] are added to it, we obtain an adjusted distribution figure of 494,959 thousand tons. This compares favorably with the figure of 494,862 thousand tons shown in Table C-2 as total U.S. consumption of bituminous coal for that year. We estimate state consumption within consumer class by apportioning the difference between total U.S. shipments and U.S. consumption in each consumer class by the existing distribution ratios in each state.

3. User Categories

The user categories used in the Bureau of Mines publications (see Table C-1) more or less coincide with the user categories required for this project. Shipments to "retail dealers" are equivalent to the coal shipped to residential and commercial users, and the category "all other" is approximately equal to our industrial category. Shipments to coke and gas plants and to electric utilities are not included in this project, since the fuel used at those facilities is reported in the NEDS point source file.

The consumption category, "retail deliveries to other consumers" (see Table C-2), is equivalent to residential and commercial consumption. Industrial consumption is the equivalent of the sum of "other manufacturing and mining industries" and "steel and rolling mills" (see Table C-2). The category "steel and rolling mills" is primarily consumption by steel and rolling mills in boilers. The use of coal in coking by the iron and steel industry is included in the category "coking coal" in Table C-2.

The derived state-by-state consumption of bituminous coal is shown for selected states in Table C-3.

B. ANTHRACITE COAL

1. Sources

There are two sources of data on the shipments of anthracite coal by state: (1) the U.S. Bureau of Mines Mineral Industry Survey [9] entitled,

TABLE C-3

ESTIMATED BITUMINOUS COAL CONSUMPTION BY CONSUMER CLASS IN ELEVEN SELECTED STATE GROUPINGS, 1971

(Excluding Coke and Gas Plants, Electric Utilities, and Vessel Fuel)

	Residential and Commercial	Industrial	Total
Alabama & Mississippi	106	2,725	2,831
California	3	15	18
Colorado	223	370	593
Florida & Georgia	81	492	573
Maryland & Delaware	43	844	887
Massachusetts	15	98	113
Missouri	77	1,429	1,506
New Hampshire, Maine, Vermont, & Rhode Island	7	68	75
South & North Dakota	151	444	595
Texas, Arkansas, Louisiana, & Oklahoma	4	46	50
Washington & Oregon	91	338	429
U.S. TOTAL	11,351	77,422	88,773

"Distribution of Pennsylvania Anthracite," and (2) the Pennsylvania Department of Environmental Resources [59]. The *Mineral Industry Survey* is the source for the data later published in the *Energy Fact Sheets* [55], while the second source is used for data published in the *Mineral Yearbook* [27]. Neither these two sources nor the National Coal Association develops data on consumption within each state by consumer class. The Bureau of Mines does estimate national consumption by consumer class in the *Mineral Industry Survey: Pennsylvania Anthracite Weekly* [60], which is later published in the *Mineral Yearbook* [27].

In 1972, the Bureau of Mines *Mineral Industry Survey* switched from reporting on a coal year (April to March) to a calendar year. Accordingly, the two data series will be compared for 1972 instead of 1971.

The national consumption data are compiled from reports on colliery, electric utility, cement, coke, sintering, and other industrial users; the residential-commercial consumption of anthracite is estimated as the remainder of U.S. production minus exports. The distribution data for both series are from a 100% survey of sales agents, wholesalers, and dock operators.

The information above is summarized in Table C-4. National consumption estimates by user category, not available on a per state basis, are given at the bottom of this table. It is evident that neither data series on shipments accounts for all the anthracite consumed. The total distribution of either series falls short of the estimated U.S. consumption of 5,915 thousand short tons. The Pennsylvani series does not, however, include dredge coal. When the annual dredge coal production of 476,792 tons and the colliery consumption of 11,298 tons are added to the total shipments, the total of 6,345,090 is 7% higher than the estimated consumption. The Bureau of Mines shipments, including colliery consumption, total 5,554,148 tons, or 7% less than the estimated consumption.

The Bureau of Mines is not able to explain the short-fall between their distribution series and the Pennsylvania series. While each series differs by approximately the same amount from the estimated consumption, they differ in their presentation of state data. The Pennsylvania series includes

TABLE C-4

ANTHRACITE SHIPMENTS IN 1972

(Short Tons)

State	Data Source Bureau of Mines M.I.S.	 Pennsylvania and Mineral Yearbook	Estimated Residential Market Share of Anthracite
Connecticut	6,795	2,555*	90
Maine	7,903	7,903*	90
New Hampshire	5,028	3,519*	90
Vermont	11,126	10,317*	90
Massachusetts	27,838	23,536*	90
Rhode Island	1,264	1,066*	90
New Jersey	181,699	174,000	90
New York	742,907	722,000	90
Pennsylvania	3,816,208	4,207,000	90
Illinois	51,218	47,000*	—
Indiana	42,639	42,000*	5
Michigan	57,305	49,000*	5
Ohio	128,785	124,000*	10
Wisconsin	8,525	10,000*	—
Iowa	(1)	31,000*	—
Minnesota	10,405	10,000*	—
Missouri	(1)	30,000*	—
Delaware	16,585	20,000	90
Maryland	37,356	25,000	90
District of Columbia	7,013	3,000	90
Virginia	3,894	3,000*	—
Other States	378,357	290,000	
U.S. TOTAL	5,542,850	5,837,000	

(1) Included in Other States

* Rail shipments only; truck shipments included in Other States.

Estimated Consumption (10^3 Tons) (By Bureau of Mines)

Residential and Commercial	Colliery	Elect. Utilities	Iron and Steel	Other	Total
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

one extra state in its state-by-state breakdown, but, on the other hand, shows only rail shipments. Any truck shipments to these states are reported under the category "other states," causing the state figures to be less complete.

Based on these factors, we have decided to use the Bureau of Mines series for estimating the consumption of anthracite coal by state. In addition, this publication is somewhat more easily obtained.

2. Distribution Versus Consumption

The difference between total shipments, after adding the colliery consumption to the Pennsylvania series, and total estimated consumption will be apportioned to each state by the existing distribution ratio.

3. User Categories

The rightmost column in Table C-4 shows the estimated residential market share of anthracite coal. These figures were developed from several telephone interviews with individuals referred to us by the National Coal Association [61]. Residential anthracite consumption can be estimated from these figures and calculations from the Census of Housing [34]. From the above-mentioned interviews, it was learned that practically all the anthracite shipped to states other than the fifteen listed in the residential market share column of Table C-4 is consumed by industry.

In the remaining states, the total residential/commercial consumption can be estimated by subtracting the NEDS industrial point sources from total shipments. Residential use is estimated as outlined in the preceding paragraph, with the remainder considered commercial consumption.

The derived state-by-state consumption of anthracite coal is shown for selected states in Table C-5. This table assumes zero industrial consumption of anthracite because the NEDS point source data were not available.

C. NATURAL GAS

1. Sources

Three sources of data are available on the sales of natural gas within each state by consumer class.

TABLE C-5

ESTIMATED ANTHRACITE COAL CONSUMPTION BY CONSUMER CLASS IN ELEVEN SELECTED STATES FOR 1971

State	Residential and Commercial	Industrial	Total
Alabama	0	*	*
California	0	*	*
Colorado	0	*	*
Florida	0	*	*
Maryland	39,783	(1)	37,356
Massachusetts	29,647	(1)	20,647
Missouri	0	*	*
New Hampshire	5,355	(1)	5,355
South Dakota	0	*	*
Texas	0	*	*
Washington	0	*	*
Other States	0	402,939	402,939
U.S. TOTAL			5,915,000

* Included in Other States

(1) Assumed to be zero, will be equal to NEDS industrial point sources; residential and commercial classes will be adjusted accordingly

(a) The Bureau of Mines Mineral Industry Survey: Natural Gas Production and Consumption [6] contains three tables which together account for the disposition of all the natural gas produced or imported in this country. This information is summarized in Table C-6. It is identical to the information later published in the Mineral Yearbook [27] and is reconcilable with the consumption data in Energy Fact Sheets [55]. Residential and commercial consumption are the same in both publications, while industrial consumption in the Energy Fact Sheets equals "industrial," "other," "pipeline fuel," and "lease and plant fuel" in the Mineral Industry Survey. The category "other" in the Energy Fact Sheets is reported as "transmission loss" in the Mineral Industry Survey.

The Mineral Industry Survey is compiled from surveys of producers, pipelines, and distributors. All producers and pipelines are included, while about 80% of all distribution of natural gas is covered. This is extrapolated to cover all distribution by use of the production and pipeline surveys and the previous year's distribution. A facsimile of the distribution questionnaire is shown in Figure C-2.

(b) The American Gas Association annually collects and publishes sales data by state and by consumer class in Gas Facts [62]. These are shown in Table C-7. There is a significant difference between the Bureau of Mines and the A.G.A. data. As shown in Table C-8, the A.G.A. is consistently reporting a total sales volume which averages 85% of what the Bureau of Mines reports. While neither organization can definitely explain this difference, the A.G.A. does suggest that the principal reason is their non-coverage of direct sales from producers to consumers. This is supported by their closer agreement in the residential and commercial categories and their greater spread in industrial and electric categories, where direct sales would most often occur. In addition, it is unlikely that the Bureau of Mines sales data are too high, since they are able to reconcile their sales data with production data. The Bureau of Mines data seem to be a more complete estimate of natural gas consumption.

The A.G.A. data are developed from a 90% survey of gas distribution companies, extrapolated to 100% by revenues. Two different questionnaires are used; a facsimile of the short form, sent to companies with revenues of less than $3,000,000, is shown in Figure C-3.

TABLE C-6. NATURAL GAS AS REPORTED IN THE MINERALS YEARBOOK, 1971 (Million Cubic Ft.)

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Delivered to consumers	Pipeline fuel	Lease and plant fuel	Extraction loss	Total	Transmission loss and unaccounted for	Consumption
									cubic feet)¹			
[illegible]												
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11	--	--	61,434	1,455	61,434
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	--	12,088	317	12,088
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	656	--	--	156,451	1,913	156,451
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24	--	--	25,662	44	25,662
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	728	--	--	255,635	3,759	255,635
[illegible]												
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	671	--	--	326,768	14,581	326,768
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3,117	30	--	716,550	28,642	716,550
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	27,809	2,449	55	802,168	20,362	802,168
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	32,167	2,479	55	1,845,486	63,585	1,845,486
[illegible]												
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	697	13,520	1,242,797	8,391	1,242,797
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	--	566,996	6,976	566,996
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2,115	2,013	852,575	-8,640	852,575
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4,392	--	1,087,126	6,539	1,087,126
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	--	348,132	963	348,132
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	69,316	6,854	15,533	4,097,626	13,232	4,097,626
[illegible]												
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	--	344,639	2,520	344,639
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	27,992	39,141	646,730	16,386	646,730
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	--	351,442	9,152	351,442
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	--	429,105	5,311	429,105
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1,275	599	221,273	-12,341	221,273
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13,050	3,582	37,169	617	37,169
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6	--	--	31,842	162	31,842
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	43,337	43,322	2,065,190	21,804	2,065,190
[illegible]												
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	--	26,452	291	26,452
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	274	180	336,901	914	336,901
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	--	342,679	11,050	342,679
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	451	--	188,371	3,859	188,371
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	--	160,567	3,854	160,567
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	213	--	156,263	3,142	156,263
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	--	141,014	4,155	141,014
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3,643	10,939	189,319	-19,793	189,319
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	39,481	4,001	11,119	1,541,466	7,472	1,541,466
[illegible]												
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	476	281	286,254	-6,787	286,254
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2,212	6,123	250,493	2,582	250,493
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6,500	1,217	379,538	9,639	379,538
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1,524	--	265,011	8,818	265,011
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	141,916	10,652	7,621	1,181,296	14,252	1,181,296
[illegible]												
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2,563	336,207	19,063	336,207
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	193,972	2,578,996	23,081	2,578,996
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15,914	667,496	13,853	667,496
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	489,298	4,013,016	84,859	4,013,016
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	212,904	1,164,971	701,637	7,595,715	140,856	7,595,715
[illegible]												
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	50	--	213,313	4,038	213,313
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3,281	4,183	293,521	3,079	293,521
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	--	50,096	1,458	50,096
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6,110	780	89,021	3,745	89,021
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	--	--	66,511	1,451	66,511
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	46,114	53,810	323,178	11,891	323,178
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	505	2,115	3,822	125,225	1,764	125,225
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20,748	12,802	128,088	2,256	128,088
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	91,471	78,366	75,336	1,288,953	29,676	1,288,953
[illegible]												
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6,450	98	67,805	3,582	67,805
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15,241	27,586	2,176,849	36,126	2,176,849
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	--	100,897	1,915	100,897
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	--	156,663	2,715	156,663
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2,311,988	[illegible]	[illegible]	27,684	2,502,214	44,338	2,502,214
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	338,274	[illegible]	742,592	1,413,650	883,127	22,676,581	338,999	22,676,581

Form 6-1340-A
F. Fuels (6-73)

B25

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
WASHINGTON, D.C. 20240

SUPPLY AND DISPOSITION OF NATURAL GAS
(Non-producing distributor's report)

O.M.B. No. 42-R0052.
Approval expires November 30, 1977.

INDIVIDUAL COMPANY DATA—CONFIDENTIAL

The data furnished in this report will be treated in confidence by the Department of the Interior, except that they may be disclosed to Federal defense agencies.

Figure C-2. Questionnaire Used by the Bureau of Mines

Reproduced from best available copy.

(Please correct if name or address has changed.)

Please complete the following form and return ONE COPY. Report all gas volumes at the pressure base of 14.73 pounds per square inch absolute at 60°F. See instructions on reverse side.

I. STATE covered by this report: ____________________

II. Supply and disposition of natural gas during the year

Item (1)	Code	Quantity (Million cubic feet) (2)	Value (Thousands of dollars) (3)
A. Supply:			
1. Received from producing companies in State designated in Item 1	163		
2. Received from pipeline companies: (Name of company) ________________	171		
________________			
________________			
3. Withdrawn from underground storage	181		
4. Total supply	199		
B. Disposition:			
1. Delivered directly to:			
a. Residential consumers	271		$
(1) Number of residential consumers at end of year ☐	371		
b. Commercial consumers	272		$
(1) Number of commercial consumers at end of year ☐	372		
c. Industrial consumers	273		$
d. Electric utilities	274		$
e. Other consumers	275		$
2. Own company use	276		$
3. Stored in underground storage	281		
4. Unaccounted for	298		
5. Total disposition (should equal A4)	299		

Signature	Title	Date

TABLE C-7

GAS UTILITY INDUSTRY SALES
BY STATE AND CLASS OF SERVICE FOR 1971
(Trillions of BTUs)

Division and State	Total	Class of Service			
		Residential	Commercial	Industrial	Other
United States	16,679.5	5,039.7	2,155.5	8,643.4	840.9
New England	259.6	141.5	50.6	57.9	9.7
Connecticut	62.9	32.3	11.4	19.1	0.1
Maine	1.8	0.8	0.4	0.5	0.1
Massachusetts	157.4	90.5	32.1	26.4	8.7
New Hampshire	7.2	3.9	1.5	1.3	0.5
Rhode Island	27.2	12.8	4.8	9.3	0.3
Vermont	3.1	1.2	0.5	1.4	0.0
Middle Atlantic	1,714.9	828.7	273.6	578.0	31.6
New Jersey	309.1	[illegible]	60.7	97.7	2.1
New York	618.8	361.1	105.7	129.7	23.3
Pennsylvania	787.1	319.9	107.2	351.7	9.2
East North Central	4,072.1	1,572.4	669.8	1,758.4	71.5
Illinois	1,167.4	465.1	203.2	482.2	16.8
Indiana	513.9	155.2	73.0	282.9	0.9
Michigan	895.3	355.1	156.2	365.5	15.4
Ohio	1,146.0	481.8	191.9	453.3	16.9
Wiscon	350.6	114.2	45.5	171.8	19.4
West North Central	1,795.5	529.3	257.8	938.4	70.0
Iowa	319.3	95.3	57.0	142.3	24.7
Kansas	491.4	95.6	37.3	346.4	12.1
Minnesota	313.6	104.3	47.0	153.8	8.0
Missouri	423.3	159.6	70.8	179.2	13.7
Nebraska	199.4	53.9	28.4	106.4	10.7
North Dakota	19.5	8.7	8.3	2.1	0.5
South Dakota	28.9	11.5	9.0	8.1	0.4
South Atlantic	1,367.9	359.3	175.6	773.0	60.0
Delaware	24.6	8.4	3.4	11.3	1.5
District of Columbia	28.0	14.6	10.3	1.0	2.1
Florida	223.6	17.6	21.6	157.6	26.3
Georgia	337.6	87.2	39.1	209.0	2.2
Maryland	154.0	74.1	18.7	58.0	3.2
North Carolina	162.6	25.9	18.5	106.0	9.3
South Carolina	133.6	30.1	12.9	84.2	6.3
Virginia	142.1	51.1	26.8	56.7	7.5
West Virginia	161.0	57.3	24.3	78.1	1.3
East South Central	986.1	216.5	117.3	629.5	23.0
Alabama	275.8	96.1	28.3	150.9	0.6
Kentucky	189.4	63.9	35.4	72.6	7.4
Mississippi	283.3	31.2	15.8	197.2	11.0
Tennessee	286.7	46.2	37.7	168.8	4.0
West South Central	3,200.4	422.1	194.8	2,323.5	260.0
Arkansas	305.5	47.0	27.9	226.1	3.5
Louisiana	728.1	71.7	34.0	679.0	12.5
Oklahoma	363.1	78.3	39.0	138.9	106.9
Texas	1,793.7	225.0	103.5	1,327.1	135.1
Mountain	960.7	244.1	144.5	539.9	32.2
Arizona	177.6	37.1	21.3	110.9	14.2
Colorado	271.1	64.8	98.8	118.5	2.0
Idaho	45.3	8.7	6.0	28.2	1.5
Montana	70.0	24.0	15.9	30.6	3.0
Nevada	70.5	8.0	6.4	55.7	0.7
New Mexico	128.0	26.7	13.1	86.9	[illegible]
Utah	117.6	43.0	16.7	55.6	0.0
Wyoming	71.0	13.0	8.0	41.8	5.7
Pacific	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Alaska	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
California	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Hawaii	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Oregon	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Washington	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Source: American Gas Association [62]

TABLE C-8

TOTAL GAS SALES

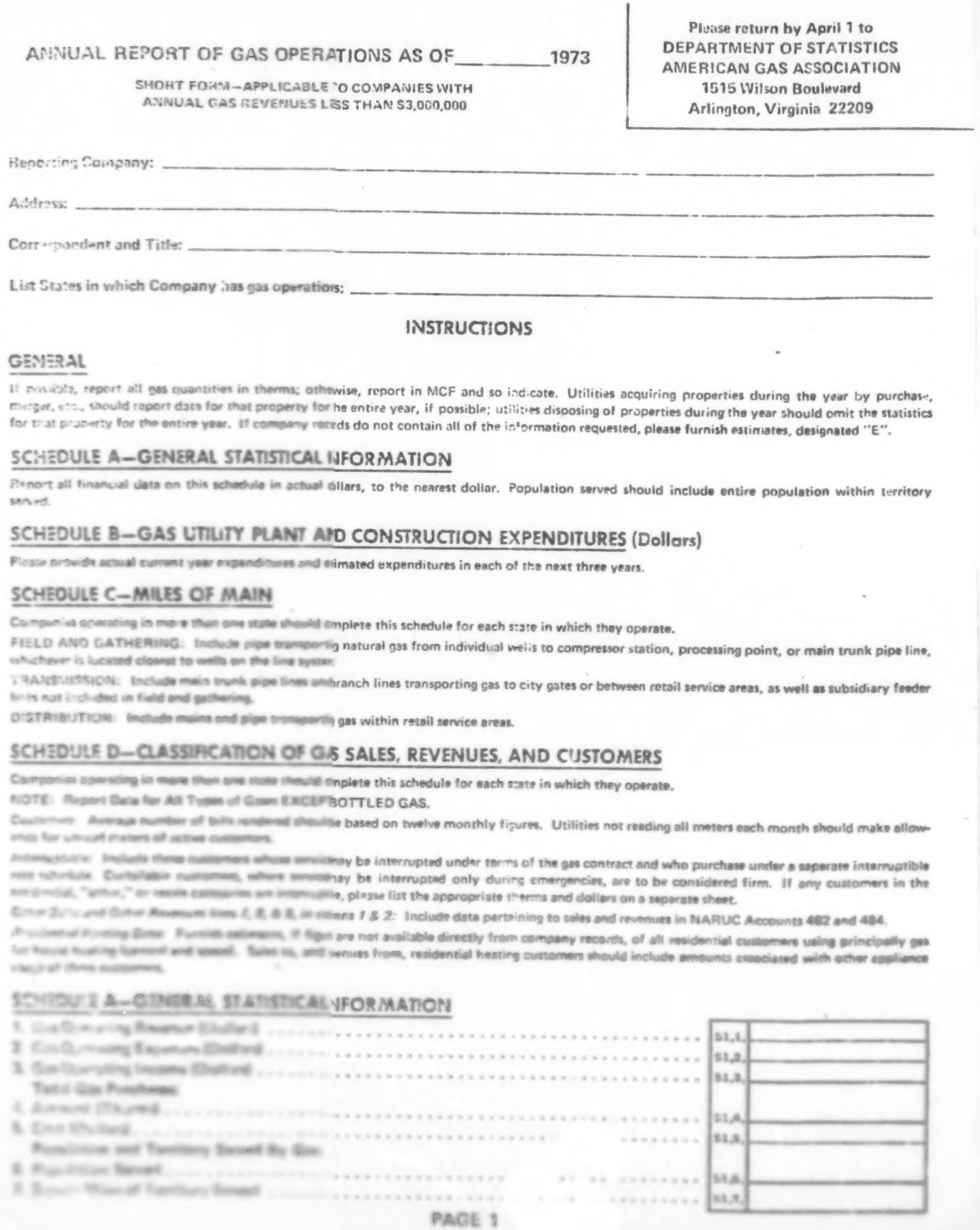
A. G. A. Data as Percent of Bureau of Mines Data

1960 - 1972

Year	Total	Residential	Commercial	Industrial and Electric
1960	86.83	99.60	87.56	73.07
1961	85.98	99.08	89.15	71.51
1962	86.27	98.61	88.02	72.50
1963	86.24	99.10	87.27	72.69
1964	86.62	99.11	90.16	73.31
1965	85.73	99.64	90.77	72.52
1966	89.27	97.73	87.32	78.70
1967	88.69	98.06	89.05	78.07
1968	84.92	99.22	91.83	71.67
1969	83.95	98.87	93.19	71.10
1970	83.23	98.62	94.54	69.40
1971	83.73	98.22	96.13	68.89
1972	85.18	97.79	97.10	70.53
Average	85.65	98.63	91.64	72.25

Gene Robert Abrams
Marketing Analyst
Department of Statistics, A. G. A.

Figure C-3. Questionnaire Used by the American Gas Association



ANNUAL REPORT OF GAS OPERATIONS AS OF ________ 1973

SHORT FORM—APPLICABLE TO COMPANIES WITH
ANNUAL GAS REVENUES LESS THAN $3,000,000

Please return by April 1 to
DEPARTMENT OF STATISTICS
AMERICAN GAS ASSOCIATION
1515 Wilson Boulevard
Arlington, Virginia 22209

Reporting Company: ______________________________

Address: ______________________________

Correspondent and Title: ______________________________

List States in which Company has gas operations: ______________________________

INSTRUCTIONS

GENERAL

If possible, report all gas quantities in therms; otherwise, report in MCF and so indicate. Utilities acquiring properties during the year by purchase, merger, etc., should report data for that property for the entire year, if possible; utilities disposing of properties during the year should omit the statistics for that property for the entire year. If company records do not contain all of the information requested, please furnish estimates, designated "E".

SCHEDULE A—GENERAL STATISTICAL INFORMATION

Report all financial data on this schedule in actual dollars, to the nearest dollar. Population served should include entire population within territory served.

SCHEDULE B—GAS UTILITY PLANT AND CONSTRUCTION EXPENDITURES (Dollars)

Please provide actual current year expenditures and estimated expenditures in each of the next three years.

SCHEDULE C—MILES OF MAIN

Companies operating in more than one state should complete this schedule for each state in which they operate.

FIELD AND GATHERING: Include pipe transporting natural gas from individual wells to compressor station, processing point, or main trunk pipe line, whichever is located closest to wells on the line system.

TRANSMISSION: Include main trunk pipe lines and branch lines transporting gas to city gates or between retail service areas, as well as subsidiary feeder lines not included in field and gathering.

DISTRIBUTION: Include mains and pipe transporting gas within retail service areas.

SCHEDULE D—CLASSIFICATION OF GAS SALES, REVENUES, AND CUSTOMERS

Companies operating in more than one state should complete this schedule for each state in which they operate.

NOTE: Report Data for All Types of Gas EXCEPT BOTTLED GAS.

Customers: Average number of bills rendered should be based on twelve monthly figures. Utilities not reading all meters each month should make allowance for unread meters of active customers.

Interruptible: Include those customers whose service may be interrupted under terms of the gas contract and who purchase under a seperate interruptible rate schedule. Curtailable customers, whose service may be interrupted only during emergencies, are to be considered firm. If any customers in the residential, "other," or resale categories are interruptible, please list the appropriate therms and dollars on a separate sheet.

Other Sales and Other Revenues lines 7, 8, & 9, in columns 1 & 2: Include data pertaining to sales and revenues in NARUC Accounts 482 and 484.

Residential Heating Data: Furnish estimates, if figures are not available directly from company records, of all residential customers using principally gas for house heating (central and space). Sales to, and revenues from, residential heating customers should include amounts associated with other appliance usage of these customers.

SCHEDULE A—GENERAL STATISTICAL INFORMATION

1. Gas Operating Revenue (Dollars)	S1,1,	
2. Gas Operating Expenses (Dollars)	S1,2,	
3. Gas Operating Income (Dollars)	S1,3,	
Total Gas Purchases		
4. Amount (Therms)	S1,4,	
5. Cost (Dollars)	S1,5,	
Population and Territory Served By Gas		
6. Population Served	S1,6,	
7. Square Miles of Territory Served	S1,7,	

PAGE 1

Figure C-3 (continued)

PAGE 2 ANNUAL REPORT OF GAS OPERATIONS AS OF __________ 1973 PAGE 2

Company ______________________ State of ______________________ Total System ☐

DO NOT FILL IN – A.G.A. Use Only

	Year	Region	State	Co. Type	Co. Code	Release
HEADING,	1973,	______,	______,	______,	______,	______

SCHEDULE B—GAS UTILITY PLANT AND CONSTRUCTION EXPENDITURES (Dollars)

		GROSS UTILITY PLANT	GAS CONSTRUCTION EXPENDITURES			
			1973	1974	1975	1976
1. Intangible Plant	50,1,					
2. Production	50,2,					
3. Underground Storage	50,3,					
4. Other Storage	50,4,					
5. Transmission	50,5,					
6. Distribution	50,6,					
7. General	50,7,					
8. TOTAL GAS PLANT	50,8,					

SCHEDULE C—MILES OF MAIN

Miles of Main as of December 31		STEEL	PLASTIC (Including Fiberglass)	OTHER
1. Field and Gathering	26,1,...			
2. Underground Storage	26,2,...			
3. Transmission	26,3,...			
4. Distribution	26,4,...			
5. Service Piping	26,7,...			
6. TOTAL MILES	26,10,...			

SCHEDULE D—CLASSIFICATION OF GAS SALES, REVENUES AND CUSTOMERS

		SALES (Therms) Column 1	REVENUES (Dollars) Column 2	CUSTOMERS Average Column 3
RESIDENTIAL				
1. With Heating	20,1,			
2. Without Heating	20,2,			
COMMERCIAL				
3. Firm	20,3,			
4. Interruptible	20,4,			
INDUSTRIAL				
5. Firm	20,5,			
6. Interruptible	20,6,			
OTHER				
7. Municipal and Other Public Authorities	20,7,			
8. Interdepartmental	20,8,			
9. Other	20,9,			
10. TOTAL SALES TO CONSUMERS	20,10,			
11. Other Gas Utilities (for Resale)	20,11,			
12. TOTAL GAS SERVICE SALES	20,12,			
13. Other Gas Revenues	20,13,	XXXXXXXXXXX		
14. TOTAL GAS OPERATING REVENUES	20,14,	XXXXXXXXXXX		
Average Btu as Distributed	20,15,			

(c) The third source of data on natural gas consumption is Brown's Directory of North American Gas Companies [48], which publishes annual sales by each company by consumer class. It distinguishes between heating and non-heating residential customers. However, this information is incomplete for many of the smaller companies, where sales are only reported as a total. The company sales data in Brown's, when totalled for each state, fluctuate above and below the state consumption data in the Mineral Industry Survey, due in part to a difference in the definition of industrial consumption. Also, when using Brown's, it is difficult to account for interstate transfers. Due to this problem and the incomplete reporting by some companies, Brown's is not suitable for developing state totals of gas consumption.

In conclusion, we consider the natural gas sales reported by the Bureau of Mines to be the most accurate statewide consumption estimates available. The user categories are as required for this project.

D. LIQUIFIED PETROLEUM GAS (LPG)

1. Sources

The sole generator of data on LPG sales is the Bureau of Mines; they are reported annually in the M.I.S. Sales of Liquified Petroleum Gas and Ethane [8]. This is the source of data later published by the National Liquified Petroleum Gas Association [63]. The Bureau of Mines data are shown in Table C-9.

These statistics are compiled from a survey of companies selling in excess of 100,000 gallons, accounting for 84% of all consumption. The total is extrapolated from district demand information on the Bureau of Mines monthly petroleum statement [64]. A facsimile of the survey is shown in Figure C-4.

2. Sales Versus Consumption

We assume the LPG sales data shown in Table C-9 to equal consumption. We are aware of a small error factor which is introduced here due to the storage capabilities available to the ultimate consumer. It is felt, however, that this error is too small to warrant further research into this matter.

TABLE C-9

SALES OF LIQUIFIED PETROLEUM GASES AND ETHANE BY USE, EXCLUDING USE IN GASOLINE PRODUCTION, BY P.A.D. DISTRICT AND STATE: 1972 AND 1971

(Thousand Gallons)

Reproduced from best available copy.

[illegible]

Sales of liquefied petroleum gases and ethane during the year by States of destination and by uses
(See instructions and definitions on reverse side)

(Insert names of States in column headings) →

Uses and products	Code	1,000 gals.	1,000 gals.	1,000 gals.	1,000 gals.
A. Direct sales to consumers by your company:					
1. Residential and commercial uses:					
a. Propane	201				
b. Butane	301				
c. Butane-propane mixtures	401				
2. Internal-combustion engine fuel:					
a. Propane	202				
b. Butane	302				
c. Butane-propane mixtures	402				
3. Industrial uses *(incl. petroleum refinery fuel)*:					
a. Ethane	103				
b. Propane	203				
c. Butane	303				
d. Butane-propane mixtures	403				
4. Gas distribution companies:					
a. Ethane	104				
b. Propane	204				
c. Butane	304				
d. Butane-propane mixtures	404				
5. Raw materials and solvents for chemical plants:					
a. Ethane-ethylene	105				
b. Propane	205				
c. Butane-isobutane	305				
d. Butane-propane mixtures	405				
6. Substitute *(synthetic)* natural gas feedstock:					
a. Ethane	112				
b. Propane	212				
c. Butane	312				
d. Butane-propane mixtures	412				
7. Agricultural uses:					
a. Propane	213				
b. Butane	313				
c. Butane-propane mixtures	413				
8. All other uses:					
a. Propane	208				
b. Butane	308				
c. Butane-propane mixtures	408				
B. Sales to dealers, resellers, producers, and to refineries for gasoline blending:					
a. Ethane-ethylene	109				
b. Propane	209				
c. Butane-isobutane	309				
d. Butane-propane mixtures	409				
C. Total sales *(Sum of A and B)*:					
a. Ethane-ethylene	111				
b. Propane	211				
c. Butane-isobutane	311				
d. Butane-propane mixtures	411				

If this company changed ownership during the year, please report name and address of present owner, and date sold:

Figure C-4. Questionnaire Used by the Bureau of Mines for LPG

(Name) Address) (Date sold)

Signature Title Date

3. User Categories

The residential and commercial categories are lumped together in the LPG sales statistics shown in Table C-9. The residential consumption of LPG is estimated based on the number of housing units using LPG for heating in each county [4]. The state total use of residential LPG is the sum of these county estimates and can be subtracted from the reported residential/commercial category to obtain the commercial use of LPG. The industrial category is reported separately and can be used as is. The categories "internal combustion engine fuel" and "utility" and "miscellaneous uses" are not included here.

E. SUMMARY OF DATA SERIES TO BE USED FOR STATE COAL AND GAS CONSUMPTION

1. Bituminous Coal

U.S. Bureau of Mines, M.I.S. Bituminous Coal and Lignite Distribution Quarterly [10]

U.S. Bureau of Mines, M.I.S. Weekly Coal Report [58]

2. Anthracite Coal

U.S. Bureau of Mines, M.I.S. Distribution of Pennsylvania Anthracite [9]

U.S. Bureau of Mines, M.I.S. Pennsylvania Anthracite Weekly [60]

3. Natural Gas

U.S. Bureau of Mines, M.I.S. Natural Gas Production and Consumption [6]

4. LPG

U.S. Bureau of Mines, M.I.S. Sales of Liquified Petroleum Gas and Ethane [8]

F. COMPARISON WITH CENSUS OF MANUFACTURES FUEL DATA

For 1971, the Census of Manufactures published a Special Report on the use of fuel and energy by manufacturing enterprises [14]. Table C-10 shows a comparison of the industrial coal and gas consumption data derived by means of

TABLE C-10

COMPARISON OF BUREAU OF MINES BASED ESTIMATES OF INDUSTRIAL FUEL USE AND 1972 CENSUS OF MANUFACTURES, FUEL AND ELECTRICAL ENERGY CONSUMED, FOR ELEVEN SELECTED STATE GROUPINGS, 1971

Natural Gas, McF	Bureau of Mines	Census	Difference	Census as % of BuMines
Alabama	163,370	157,600	5,770	96.4
California	623,006	467,600	155,406	75.1
Colorado	76,428	40,800	35,628	53.4
Florida	97,963	73,700	24,263	75.2
Maryland & District of Columbia	47,781	38,900	8,881	81.4
Massachusetts	25,453	24,700	753	97.0
Missouri	108,231	99,600	8,631	92.0
New Hampshire, Maine & Vermont	2,697	4,000	-1,303	148.3
South Dakota	5,480	200	5,280	3.6
Texas	1,933,233	1,565,200	368,033	80.9
Washington	95,974	90,300	5,674	94.1
TOTAL, 14 States	3,179,616	2,562,600	617,016	80.6

Bituminous Coal, 10^3 Tons	Bureau of Mines (Bituminous Only)	Census	Difference	Census as % of BuMines
Alabama & Mississippi	2,725	1,916	809	70.3
California	15	16	-1	106.7
Colorado	370	276	94	74.6
Florida & Georgia	492	633	-141	128.7
Maryland & Delaware	844	906	-62	107.3
Massachusetts	98	33	65	33.7
Missouri	1,429	1,414	15	99.0
N.H., Maine, Vermont & R.I.	68	41	27	60.2
S. Dakota & N. Dakota	444	60	384	13.5
Texas,Arkansas,Louisiana & Oklahoma	46	1,175	1,129	2,554.3
Washington & Oregon	338	125	213	37.0
TOTAL, 22 States	6,869	6,595	274	96.0

the methods discussed above and the statistics published by the Census of Manufactures.

There are some fairly large discrepancies between these two sources. In general, the discrepancies are high for those states in which the particular fuel is very little used in comparison to other fuels, e.g., gas use in New Hampshire, Maine, and Vermont; coal use in all the New England states, South and North Dakota, Washington, and Oregon. This fact seems to indicate that the Census of Manufactures sample was probably not large enough for those fuels in those states to arrive at the total statistical universe.

APPENDIX D

ALTERNATIVE METHODOLOGIES FOR ALLOCATING RAILROAD USE OF DIESEL FUEL

A. COUNTY APPORTIONMENT ACCORDING TO ENERGY CONSUMPTION

Using the results of a recent Department of Transportation study, the energy requirements for railroads many be expressed as follows [65]:

$$\varepsilon = \left(\frac{e * \ell}{\eta}\right) + \left(\frac{r * t}{w}\right)$$

where ε = Fuel requirement (lb/ton)
e = Rail energy consumption (HP-hr/ton-mile)
ℓ = Distance (miles)
η = Engine efficiency factor (HR-hr/lb)
r = Fuel consumption rate at idle (lb/hr)
t = Idling times associated with run of distance ℓ (hours)
w = net load (tons)

Subsequent attempts to find data for the variables identified in the above expression on a county basis are summarized below.

1. Railroad Mileage

Railroad mileage statistics are available by state from the Association of American Railroads [66]. However, the A.A.R. does not publish or collect any county statistics on railroad mileage.

The Rand McNally Handy Railroad Atlas of the U.S. [67] provides a map of each state indicating all rail lines and the mileage on each section from station to station. These maps do not show the county boudnaries, but these can be found in Rand McNally's Commercial Marketing Atlas. The procedure would then be to estimate the number of railroad miles within each county, using the two atlases. This approach is very time-consuming. Furthermore, mileage information without any density data would not be a useful distributive factor.

2. Railroad Traffic Density

A complete survey of the rail services for the Midwest and Northeast regions was undertaken recently by the Department of Transportation [68]. This study subdivides the regions into 323 zones which follow SMSA and/or county boundaries. Rail traffic density for each line in each zone is given. Similar studies may be made of the rail service in other regions of the country in the future [69].

Whereas the density information available for a limited number of states is considered a more accurate distributive factor than railroad mileage, it still contains two major drawbacks:

- Engine idle time is not explained by this variable
- For those counties where the carload variable can be used, considerable time has to be spent in trying to match the traffic zone boundaries to the county boundaries required for this study.

Insofar as there is significant variation in the idle times from one railroad line to the next and the idling mode can account for as much as 50% of the total fuel consumption, the inability to quantify this variable would introduce a number of uncertainties into this approach.

3. Ton-Miles

The Census of Transportation compiles ton-miles for railroads for the census year on a state-by-state basis. Ton-mileage data, however, are not disaggregated to the county level.

4. Population

The method adopted for allocation of statewide railroad use of diesel fuel to counties is to apportion the state total according to population distribution. This decision is based on the following considerations:

- Distribution of railroad diesel by the Department of Transportation energy algorithm is not viable, due to lack of data on the county level

- Apportioning by the time distributive factors considered above would not significantly improve the accuracy of the county estimates. Furthermore, the fact that rail fuel consumption doubles for every degree of rail grade [69] makes the topography of the county an additional variable to be accounted for
- The time involved in coding rail mileage and carloads by county would be beyond the scope of this study

Data on the use of diesel by railroads for each state are obtained from the Bureau of Mines Mineral Industry Survey [25].

APPENDIX E

NATIONAL USAGE OF ORGANIC SOLVENTS

Using the data from the Chemical Marketing Reporter[39] and the SRI Handbook [38], the national consumption of the primary solvent groups, distributed by user category, is obtained. These national consumption figures are used for the countywide allocation and are summarized in Table 3-11. A description of the basis for arriving at these 1971 consumption estimates is given below for each of the main solvent groups identified in Section III.H.1.

Special Naphthas. This group of organic solvents finds wide applications in industrial and commercial uses and accounts for an estimated 59 percent of total organic solvent consumption.

The use of special naphthas in surface coatings is obtained from SRI [38]. As shown in Figure E-1, the SRI category of aliphatic hydrocarbons is comparable to the Bureau of Mines category of special naphthas. The 700×10^6 lbs of aliphatics reported by SRI agrees fairly well with estimates by the MSA study [37]. These figures, however, do not account for solvents and thinners added by the users before application. Since the solvents used are primarily hydrocarbons, the distribution of chemical types used for surface coatings (Figure E-1) can be used to estimate the additional aliphatic hydrocarbons that must also be included. Using SRI's 3390×10^6 lbs of total solvent use for surface coatings and an assumed equal amount of hydrocarbons added by the user before application, the additional aliphatic hydrocarbon is given by

$$(3390 \times 10^6) * \left(\frac{700}{700 + 800}\right) = 1582 \times 10^6 \text{ lbs}$$

When this additional contribution is added to the raw material use, the surface coatings share of special naphthas works out to approximately 26%.

Use of special naphthas in the printing and publishing industry is derived from a 1969 survey of aliphatic solvent use in the graphic arts industries [70]. When the reported aliphatic solvents from the survey are extrapolated to the

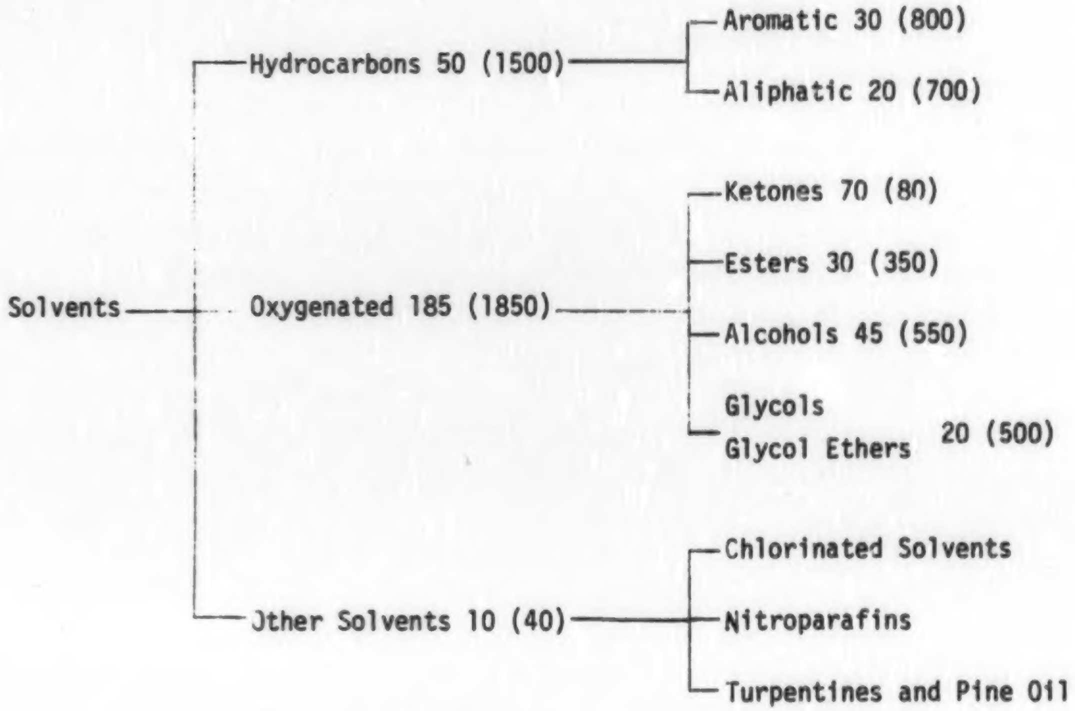

Solvents
Hydrocarbons 50 (1500)
Aromatic 30 (800)
Aliphatic 20 (700)
Oxygenated 185 (1850)
Ketones 70 (80)
Esters 30 (350)
Alcohols 45 (550)
Glycols
Glycol Ethers
20 (500)
Other Solvents 10 (40)
Chlorinated Solvents
Nitroparafins
Turpentines and Pine Oil

Figure E-1. Surface Coatings Industry
Raw Materials Used in \$ x 10^6
(And lbs x 10^6)

national level--on the basis of total employment in these industries--an estimated figure of 94 x 10^6 gallons is obtained. This consumption represents 8.25% of total demand for special naphtha for that year and, in the absence of better data, will be used in the current estimate.

In the dry cleaning industry, the use of special naphthas (e.g., stoddard solvent and safety solvent) is estimated to be about 500 x 10^6 lbs for 1971.

A recent publication [71] indicates that the use of special naphthas in degreasing applications is negligible. Similarly, no data were obtained to permit a meaningful estimate of consumption by the rubber and plastics industry. The end results of the special naphtha use analysis are shown in Table 3-11.

Perchloroethylene. The use of perchloroethylene is derived from data in the SRI Handbook [38]. Virtually all consumption was for solvent use, as shown in Table 3-11, except for 17% which was exported.

Ethanol. The SRI Handbook [38] states that 4% of all ethanol consumed in 1971 was for surface coatings, while the Chemical Marketing Reporter [39] states that total solvent use of ethanol was 39% of total consumption. Ethanol has been placed in the category "other miscellaneous solvent use."

Trichloroethylene. According to the SRI Handbook [38], all consumption of trichloroethylene was for solvent use, except for 10% which was exported. Only 3% of the total cannot be assigned to a specific industrial process.

Toluene. Only 10% of total toluene consumption was in solvent use, according to SRI [38]. About half of this use was in the surface coatings industry. A significant amount was also used in the printing and publishing industry, as recorded in the M.S.A. Hydrocarbon Pollutants Report [37]. The remaining portion of toluene used as a solvent was assigned to the printing and publishing industry.

Acetone. According to the Chemical Marketing Reporter [39], 9% of total acetone consumption was for surface coatings. The Marketing Guide to the Chemical Industry [72] states that 25% of all acetone consumption was for solvent use in 1971. Therefore, non-specific solvent use of acetone has been placed at 16%.

Xylene. The SRI Handbook [38] states that 13% of total consumption of xylene in 1971 was used as solvent. The major application of xylene is as a solvent in surface coatings. Since xylene and toluene are the two basic aromatic hydrocarbon solvents used in the surface coating industry, total toluene solvent use in the surface coating industry was subtracted from total aromatic hydrocarbon consumption in the industry, as given in Figure E-1. The remainder should be roughly the consumption of xylene in the industry. Some small amounts of benzene (also an aromatic) are also used in the industry. However, the use of benzene is so small--due to its toxicity [73]--that its exclusion here would not significantly affect the present xylene consumption estimate.

Fluorocarbons. According to the Chemical Marketing Reporter, consumption of fluorocarbons as solvents was 15% of total use in 1971, 10% of which can be distributed to the rubber industry. The listed total use of fluorocarbons as solvents at 65% reflects the use of fluorocarbons in manufacturing aerosols. Insofar as the determination of organic solvent use is for the purpose of estimating area source emissions, no distinction is necessary between fluorocarbons released from aerosol cans or from solvent use. Therefore, fluorocarbons used in manufacturing aerosols are included in the inventory of solvent use.

Methyl Ethyl Ketone (M.E.K.). The SRI Handbook [38] estimates that 65% of all M.E.K. consumed in 1971 was for solvent application in the surface coating industry. Another 7% was consumed as solvent for non-specified uses.

1,1,1-Trichloroethane. According to SRI [38], 65% of all 1,1,1-trichloroethane consumed was used as a solvent in degreasing operations. Another 9% was used in plastics and rubber production, and 11% was employed in other non-specific solvent uses.

Methylene Chloride. The Chemical Marketing Reporter [39] states that 31% of all methylene chloride consumed in 1971 was used as solvent in surface coating, 11% was used as solvent in degreasing operations, and 11% was used as solvent in the rubber and plastics industry. Another 20% of the total consumption was used in the aerosol industry and was, therefore, included in the solvent use industry. The remaining 27% was listed as miscellaneous use. Further investigation [74] revealed that all of the miscellaneous category was solvent use except for less than 10% which was exported. Total consumption of methylene chloride for solvent use is, therefore, listed as greater than 90%.

Methanol. The *Chemical Marketing Reporter* [39] lists 9% of total methanol consumption in 1971 for non-specified solvent use.

Ethylene Dichloride. According to the *Chemical Marketing Reporter* [39], 3% of all ethylene dichloride produced in 1971 was consumed as solvent in surface coating, 2% was consumed in the rubber and plastics industry, and 2.7% was employed in non-specified solvent use.

Ethyl Acetate. About 70% of the ethyl acetate consumption was for solvent use in the surface coating industry [39]. The dry cleaning industry used 9% of total consumption; 8% is attributed to the printing and publishing industry; and 10% was used as solvent in the rubber and plastics industry.

Cyclohexane According to the SRI *Handbook* [38], 2% of all cyclohexane consumed in 1971 was used as solvent in the surface coating industry. An additional 2% was used as solvent in the rubber and plastics industry.

Methyl Isobutyl Ketone (M.I.B.K.). The *Chemical Marketing Reporter* [39] estimates that 65% of all M.I.B.K. consumed in 1971 was used in the surface coating industry. An additional 25% was consumed in other non-specified solvent uses.

Other Organic Solvents. The category "other organic solvents" includes the following chemicals: hexanes, benzene, N-butanol, nitrobenzene, turpentine, isopropyl acetate, ethyl ether, monochlorobenzene, isopropanol, diethylene glycol, methyl acetate, and cresols. Their total consumption in 1971 was $11,456 \times 10^6$ lbs [27]. In 1968, about 5.2% of the total consumption of these chemicals was used as solvents [37]. Applying this to the 1971 consumption total, a figure of 591×10^6 lbs is derived for total solvent use in this category. This is less than 4% of the total of all solvent use covered in this study.

In order to determine any change in the solvent usage pattern, the total solvent use estimates of M.S.A. Research Corporation [37] for the year 1968 were compared with these estimates for the year 1971, as shown in Table E-1.

The category of "special naphthas" is 100% for both estimates because both studies use the Bureau of Mines' definition for this category, which is naphthas used as solvents. The two chemicals which show wide variations in their usage pattern between 1968 and 1971 are ethane and fluorocarbon. This discrapancy is explained by the rapid increase of their use in the production of aerosols [39]. In general, the current estimates seem to agree fairly well with those of M.S.A. Research.

TABLE E-1

PERCENT OF TOTAL CONSUMPTION USED AS SOLVENT

Solvent	M.S.A. Research, 1968	Walden, 1971
Special Naphthas	100%	100%
Perchloroethylene	89%	83%
Trichloroethylene	94%	90%
Ethanol	25%	39%
Toluene	10%	10%
Acetone	30%	25%
Xylene	9%	13%
Fluorocarbons	42%	65%
Methyl Ethyl Ketone	71%	72%
Methylene Chloride	93%	>90%
Methanol	7%	9%
Ethyl Acetate	94%	97%
Cyclo Hexane	8%	4%
Methyl Isobutyl Ketone	83%	90%
1,1,1-Trichloroethane	93%	87%
Ethylene Dichloride	5%	5%
All Other Solvents	5.16%	5.16%

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

Methods were developed to calculate the countywide consumption of anthracite and bituminous coal, natural gas and liquid petroleum gas by residential, industrial and commercial-institutional consumers. Methods were also developed to determine countywide consumption of organic solvents, gasoline and diesel fuel use by off-highway mobile sources, retail sales of gasoline and aircraft landing and take-off cycles. A procedure for estimating the sulfur and ash content of coal consumed by county was also developed. The resulting data are reported in the National Emissions Data System (NEDS) area source format. The report discusses the methodologies which were developed and presents an over-view of the computer processing schemes used to produce NEDS area source data for 1973.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Fuel consumption Coal Natural gas Organic solvents NEDS Area source		

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